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Analysis of Broadband Penetration Policy : Empirical Findings on 30 OECD Countries and Their Policy Implications

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Analysis of Broadband Penetration Policy: Empirical Findings on 30 OECD Countries and Their Policy Implications

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List of Acronyms

ADSL: Asymmetric digital subscriber line

BCDD: Broadband Commission for Digital Development

DSL: Digital subscriber line

FCC: Federal Communications Commission

FTTN: Fiber To The Notes

FTTP: Fiber To The Premises

FTTx: Fiber To The Building/Home/Cabinet

GAO: United States Government Accountability Office

ICT: Information and communications technology

ISDN: Integrated Services Digital Network

ITU: International Telecommunications Union

LLU: Local loop unbundling

OECD: Organization for Economic Cooperation and Development

PLC: Power line communications

PSTN: Public switched telephone networks

PTS: The Post and Telecom Authority

WDI: World Development Indicators

Wi-Fi: Wireless fidelity

WLAN: Wireless local area network

Abstract

The level of broadband development and the growth rate of broadband penetration are complex outcomes of many complementary factors, including socioeconomic determinants (not only income, location, education, family size, individuals' characteristics but also market structure, country's level of technological development, and other factors), regulation, and public policies. There have been a number of opinions and discussions regarding the influence of socioeconomic factors and regulation on broadband penetration. To the best of my knowledge, however, only a handful of research studies have explicitly analyzed the ex-post effectiveness of public policies for broadband promotion. To fill this research gap, this dissertation examines the public policies from both the supply and demand sides and investigates their impact on broadband penetration in selected countries. Based on the observations from these literature reviews and case studies of four countries, the following hypothesis is proposed: demand-side policies are more effective than supply-side policies to stimulate broadband penetration. Then, empirical analysis is conducted to verify the hypothesis. The results suggest that demand-side policies have a positive and significant influence in stimulating broadband penetration in OECD countries, and have a greater impact on broadband penetration than supply-side policies.

Chapter one defines the scope and purpose of this research; it presents a theoretical and empirical examination of the effect of public policy on broadband penetration.

Chapter two presents the research questions after providing a survey of the literature on the factors of broadband services, focusing on the socioeconomic drivers of broadband penetration, the interplay between regulatory factors, and direct policy factors. It is found that public policies generally fall into two groups: policies that primarily intend to increase broadband deployment and policies that largely work to promote broadband penetration. Only a handful of studies have specifically investigated the effectiveness of public policies for promotion of broadband penetration, but their conclusions are inconsistent. Besides, most of these are based on qualitative research; empirical studies are rare. This study aims to fill this research gap by investigating, both theoretically and empirically, the impact of public policies on broadband penetration.

Chapter three discusses the effects and limitations of supply- and demand-side policies. We need to seriously consider the information asymmetry between the government and market players, given a decision to subsidize operators by lowering the price of broadband. The asymmetric information relates to the status of applicants' operations and the uncertain demand of potential users. In contrast, if the policymakers intend to implement demand-side policies, such as a digital training program to raise people's willingness to pay for broadband, the limitation is that consumers may still not subscribe to the broadband service because of budget constraints. However, the advantage of demand-side policies is that the government can reduce market distortion by allowing market mechanisms to function.

Chapter four provides an in-depth analysis of public policies at the national level in four countries: the UK, Sweden, South Korea, and Australia. These countries adopted various strategies to boost broadband penetration and deployment. Sweden and South Korea were actively involved in promoting broadband penetration through both demand- and supply-side policies, and were shown to be top performers in broadband among OECD countries. Although the Australian government apparently attempted to stimulate broadband penetration by focusing only on supply-side policies, with little effort to expand demand, the country was well behind the OECD average of broadband penetration.

From these findings, broadband penetration is more likely to be demand-constrained rather than supply-constrained, public interventions on the demand side are thus much more effective than those on the supply side. Chapter five proposes three hypotheses: (1) Broadband is primarily demand-constrained and market users are the key driving forces. (2) The impact of supply-side policies on broadband penetration might be overstated. (3) Using both supply- and demand-side policies is the most effective strategy to promote broadband penetration. These hypotheses are then tested by a regression analysis based on data for 30 OECD countries from 2006 through 2008. The estimation results suggest that demand-side policies, but not supply-side policies, have a significant positive impact on broadband penetration. Demand-side policies are found to have a greater impact on broadband penetration than supply-side policies. Besides, the combination strategy has no statistically

significant influence, nor is it more effective than demand-side policies. The results stress the importance of demand-side policies to encourage broadband penetration for effective penetration of broadband technology.

Chapter six summarizes the conclusions and presents policy recommendations. The study suggests that government intervention, historically aimed at the supply side, should be directed to the demand side. Governments in technologically advanced countries or regions should place less reliance on supply-side policies.

Chapter 1 Introduction

1.1. The definition of broadband

Broadband can be generally defined as transmission technologies used for high-speed and high-capacity data communication through fixed or wireless connections. The International Telecommunications Union (ITU) defines broadband as transmission capacity that is faster than the primary-rate Integrated Services Digital Network (ISDN), at 1.5 or 2.0 megabits per second (Mbits)[1]. In spite of this definition, broadband has a wide range of meanings. This study adopts the definition used by the Organization for Economic Cooperation and Development (OECD). Consequently, broadband implies transmission speeds equal to or greater than 256 and 64 kbit/s for downstream and upstream connections, respectively (OECD, 2001, p. 6).

Broadband services are delivered through different technologies, including digital subscriber lines (DSLs), cable modems, fiber optics, and other fixed and mobile broadband technologies. The most common broadband platform is DSL (Point Topic, 2012, p. 8), which relies on an existing telecommunication copper network to provide higher speeds and greater quality than dial-up. DSL uses different frequencies to split voice and data services using the same standard phone line so that users have the ability to surf the Internet and talk

[1] The definition is provided by ITU (see https://www.itu.int/osg/spu/publications/birthofbroadband/faq.html).

on the phone at the same time[2]. Another widespread technology is the cable modem, which offers high connection speeds through cable TV networks. The main difference between DSL and cable is that all cable subscribers in a small area share the same channels to deliver data, while DLS is a dedicated service where each subscriber has his/her own private circuit to the central telephone office. Fiber optic communications permit transmission over longer distance and at higher bandwidths than DSL and cable. Unlike DSL and cable modem technologies, both based on existing copper wires, the fiber optic cable uses lasers to transmit pulses of light down extremely fine strands of silicon, and therefore has a higher cost of installation than DSL and cable modems. Other relevant technologies for broadband connection include wireless local area network (WLAN), wireless fidelity (Wi-Fi), satellite, power line communications (PLC, based on the electricity transmission network), and mobile wireless.

It is widely agreed that broadband is an important factor that stimulates productivity growth and drives a thriving global economy (BCDD, 2011, p. 7; Crandall and Singer, 2010, p. 6; Lehr, et al., 2005, p. 13; Stenberg, 2010, p. 11; Zhao and Ruan, 2009, p. 38). Broadband penetration is an essential feature of a communications infrastructure policy and is treated as a critical economic indicator, currently. Scholars have found a direct relationship between broadband access and a nation's GDP (Greenstein and McDevitt,

[2] See https://www.itu.int/osg/spu/publications/birthofbroadband/faq.html.

2011; World Bank, 2009, p. 45), more remarkable in low- and middle-income countries (Lam and Shiu, 2010). A World Bank report on information and communications technology (ICT) calculates that every 10 additional broadband subscribers for every 100 inhabitants correlate with a GDP growth of 1.21% for high-income and 1.38% for low- and middle-income countries (World Bank, 2009, p. 45). In addition, investment in broadband has been found to achieve cost savings in capital-intensive industries and develop a more educated workforce (Gulati and Yates, 2012, p. 749). Since a well-developed telecommunication infrastructure is perceived as a critical determinant of countries' competitiveness and growth potential, governments have been pursuing policies to stimulate broadband penetration and upgrade of existing networks. As early as 2004, the OECD Council adopted the Recommendation of the Council on Broadband Development, which calls on member countries to implement a set of policy principles to assist the expansion of broadband markets, promote efficient and innovative supply arrangements, and encourage effective use of broadband services (OECD, 2008, p. 3). Promoting nationwide broadband penetration has become an important national agenda in both developed and less-developed countries.

1.2. Overview of global broadband penetration status

According to ITU statistics, fixed broadband subscribers numbered only 220 million in 2005 and approximately 673 million by 2013, while the mobile-broadband subscriber base

grew from just over 268 million in 2007 to 1930 million by 2013 (ITU, 2014). Despite the rapid growth, a broadband connection for all Internet users is still a far cry. Figure 1.1 shows a wide range of fixed and mobile broadband penetration levels across countries. More than 26 persons per 100 inhabitants in developed countries, but only 5.8 in developing countries, are fixed broadband users. Similarly, more than 75% of the population use mobile broadband in developed countries as compared to around 16% in developing countries.

The penetration of broadband connections is heterogeneous not only between developed and developing countries but also among developed countries. As of December 2013, the average penetration in OECD countries was 26.96 (per 100 inhabitants) for fixed broadband and 72.37 (per 100 inhabitants) for mobile broadband (OECD, 2014). As of 2013, Switzerland, the Netherlands, Denmark, France, and Korea were the leading fixed broadband economies, and Finland, Australia, Japan, Sweden, and Denmark the top-five mobile broadband economies, among OECD countries (see Figures 1.3 and 1.4).

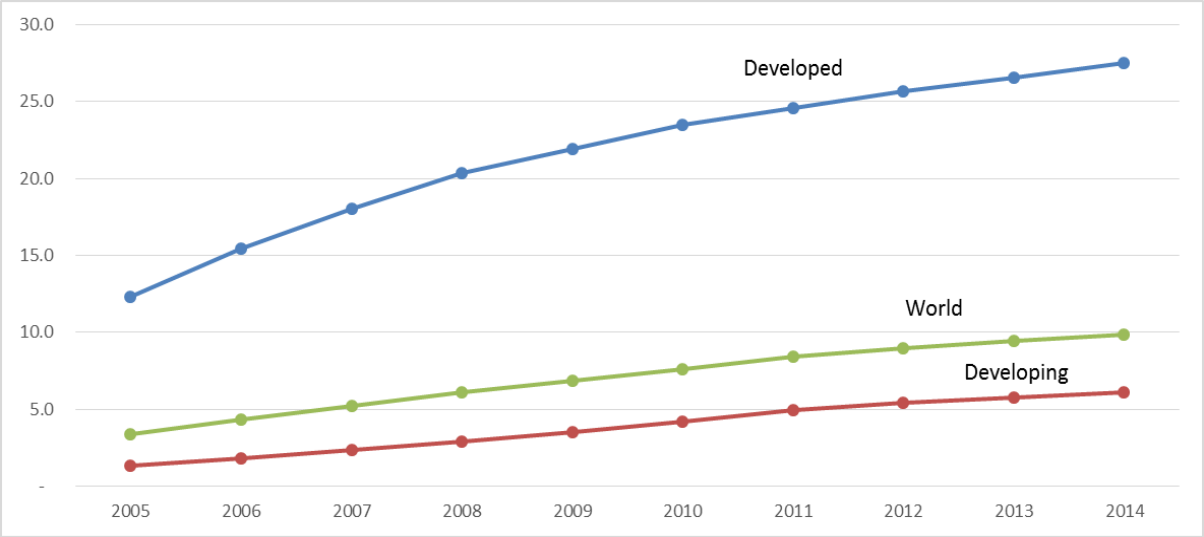

Figure 1.1 Fixed broadband subscriptions per 100 inhabitants worldwide, 2005–2014

Source: Created on the basis of ITU (2014).

Note 1: The developed/developing country classifications are based on the United Nations (UN) M49, a standard for area codes used by the UN for statistical purposes, developed and maintained by the United Nations Statistics Division. Based on the M49, countries are classified according to macro geographical regions and sub-regions, and selected economic and other groupings (see http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx).

Note 2: The ITU Standardization Sector defines broadband as a transmission capacity that is faster than the primary-rate ISDN, at 15 or 2.0 megabits per second.

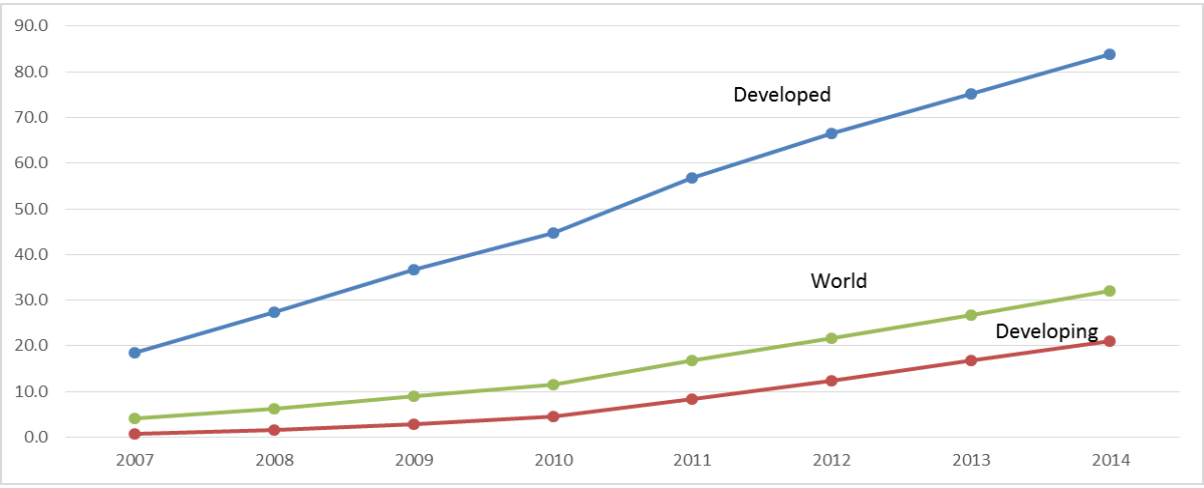

Figure 1.2 Active mobile broadband subscriptions per 100 inhabitants worldwide, 2007–2014

Source: Created on the basis of ITU (2014).

Note 1: Ibid. note 1, figure 1.1.

Note 2: Ibid. note 2, figure 1.1.

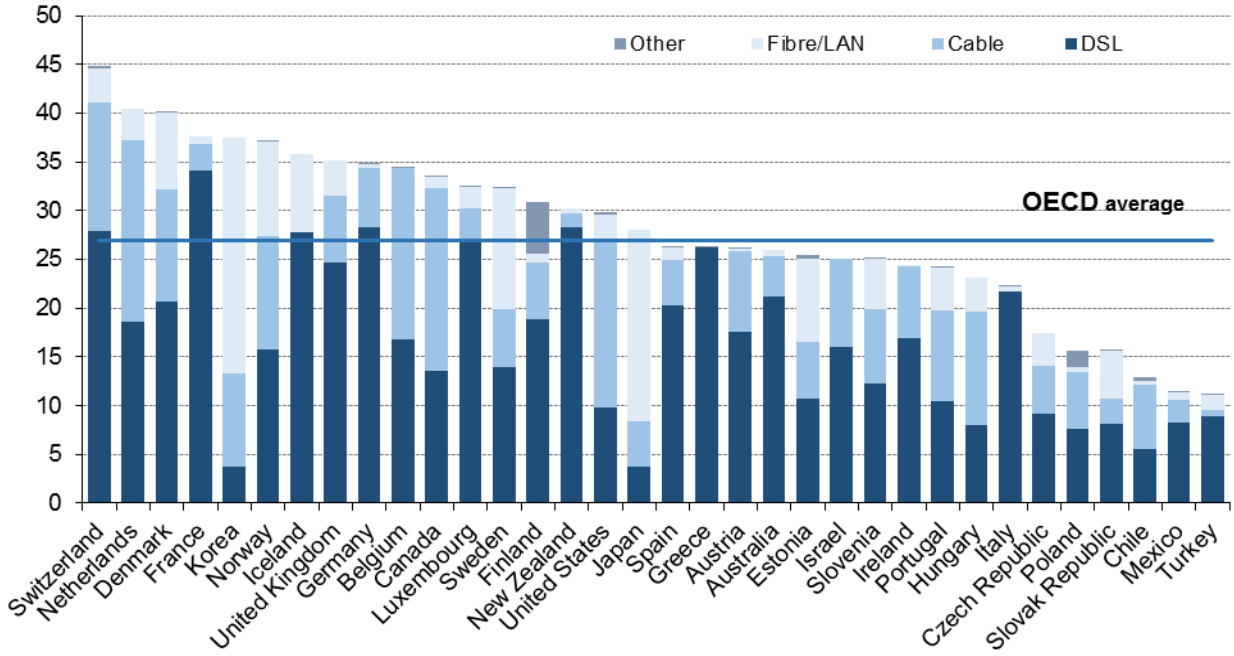

Figure 1.3 Fixed broadband subscriptions per 100 inhabitants in OECD countries, December 2013

Source: Created on the basis of OECD (2014).

Note 1: OECD defines broadband as a transmission capacity equal to or greater than 256 and 64 kbit/s for downstream and upstream connections, respectively.

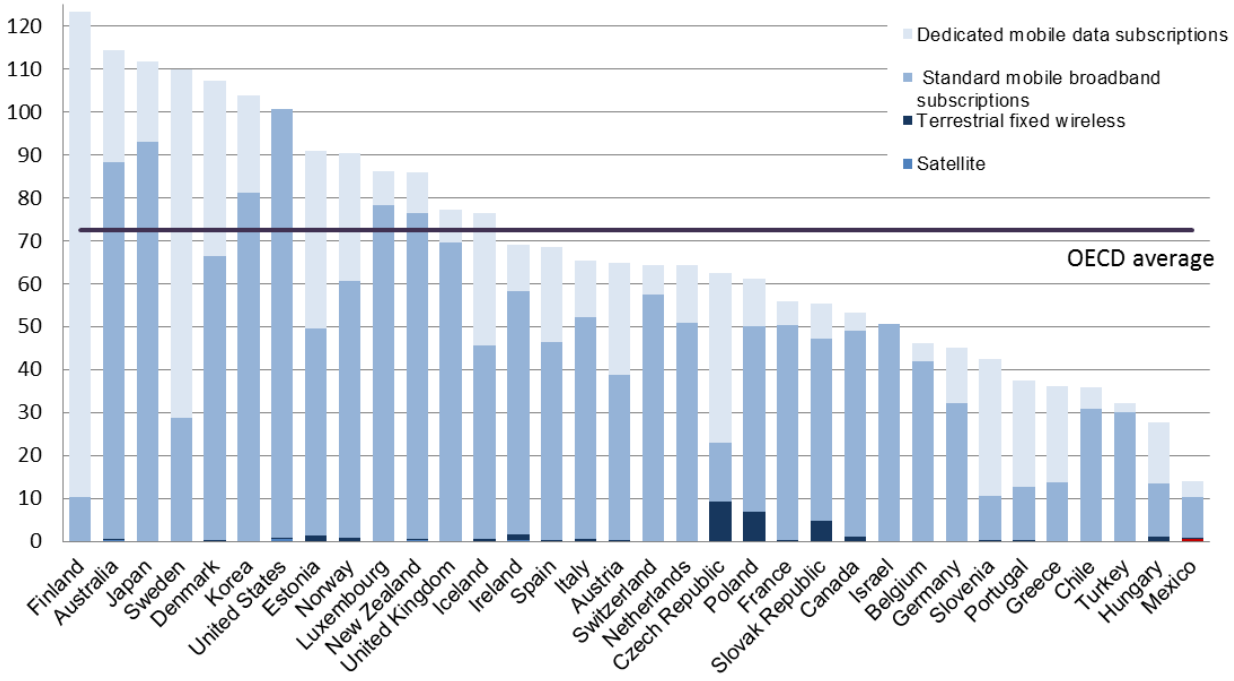

Figure 1.4 Wireless broadband subscriptions per 100 inhabitants in OECD countries, December 2013

Source: Created on the basis of OECD (2014).

Note 1: Ibid, note 1, figure 1.3.

Note 2: Dedicated mobile data subscriptions include subscriptions to dedicated data services over a mobile network purchased separately from voice services either as a stand-alone service or as an add-on data package to voice services, and require an additional subscription. Standard mobile broadband subscriptions include mobile subscriptions that advertise data speeds of 256 kbit/s or greater and which have been used to make Internet data connections via IP in the previous three months (see http://www.oecd.org/sti/broadband/broadband-methodology.htm).

1.3. The economic significance of broadband penetration

Broadband networks are an increasingly integral part of the economy. Economic growth and development are positively and directly affected by investment in broadband technologies and deployment of infrastructure. To be specific, the relevance of broadband for economic activity refers to the range of new and better applications that it enables as a platform, such as enhanced communication and video streaming, new services in e-

commerce, e-government, e-health, and e-education. Not surprisingly, broadband can improve the quality of daily life for people around the world.

For instance, the information technology and transportations sectors will be able to increase efficiency and decrease energy consumption (Lam and Shiu, 2010), while public players can enhance their efficiency by improving service delivery, creating an open and transparent government, and enhancing public safety (Federal Communications Commission, 2010, chs. 14–16). Examples of broadband's indirect effects on economic growth and development are presented in table 1.1 (Rossi, 2012, p. 11).

Table 1.1 Types of effects broadband exerts on economic growth and development

Types of effect	**Description**
Direct effects	The impact of broadband infrastructure rollout on the economy—positive influence of investments in broadband connection technologies and infrastructure deployment in terms of business activities and employment.
Indirect effects	The impact of broadband adoption on the economy.

Source: The author

Table 1.2 Examples of indirect effects that broadband exerts on economic growth and development

Examples	**Descriptions**
Encouraging innovative production	The development of broadband encourages innovation both in the technologies necessary to the building of the network and in the devices used for connecting to high-speed Internet.
Enhancing service-related activities and improving competitive dynamics in the service sector	With the advantage of broadband use, the service sector can strengthen economic integration[1], increase trade flows in business services, and create new jobs in high-value-added services (marketing, advertising, management consultancy and human resource management, for example.).
Sustaining technological improvement in the production chain	Broadband allows faster communications, creation of new services, improvement in organizational structures, faster processing of information and decision-making, and development of new and advanced skills.
Enhancing internal government efficiency	The public sector benefits from the use of broadband connection. Governments can enhance their efficiency by improving service delivery and creating an open and transparent government. For instance, e-government allows governments to interact with citizens directly.
Others	From air traffic control to rail transport and logistics management systems, from e-education to e-service for tax payments (for instance, citizens can fill in an electronic tax return form and make payments electronically), the public sector requires broadband Internet for most of its common activities.

Source: The author

Note 1: This can be explained by the fact that the availability, quality and affordability of broadband services are now important factors for international investors when deciding whether to invest in a specific country, because rapid broadband diffusion and increasing speeds and bandwidth, along with the ongoing liberalization of trade and investment in services, have increased the tradability of many service activities and created new kinds of tradable services (Qiang et al., 2009. p.43).

1.4. The purpose and structure of this thesis

Recognizing the important role of broadband penetration in economic growth and social development, many countries are seeking to develop policy frameworks that facilitate

sustained investment and stimulate user adoption. However, broadband penetration has followed different paths in different countries and regions. Several scholars have studied the factors that affect broadband penetration. Most of these studies have focused on regulations in the communication industry (Cambini and Jiang, 2009), level of market competition (Shinohara, 2014), types of competition (Distaso et al., 2006; Aron and Burnstein, 2003), network effects of broadband access services (Kuroda, 2008; Church and Gandal, 2005), and the socioeconomic determinants of broadband adoption (Flamm and Chaudhuri, 2007; Rappoport et al., 2003; GAO, 2006). Meanwhile, countries across the world have been anxiously pursuing public policies to promote broadband penetration and upgrade existing networks (for instance, the ambitious National Broadband Network, or NBN, in Australia). Various policies have been adopted by different countries over time.

Owing to the difficulty of gathering appropriate information on a sufficient number of countries for a valid policy analysis, both theoretical and empirical analyses focusing on the policy side of the broadband debate are scarce.

Although research studies explicitly assessing the ex-post effectiveness of direct public policies for broadband promotion are limited, a few authors have suggested that such policies for the telecommunication industry need to be given special attention (Falch, 2007). A comparative study on broadband policy among EU countries by Bohlin and Teppayayon (2010) also suggest that public policies can, under certain conditions, be an effective tool.

Similarly, a qualitative study by Troulos and Maglaris (2011) concludes that public policies have a positive effect on broadband penetration.

Thus, a continued role for public policy is suggested. Uncovering different factors that affect broadband penetration in a country and the role played by public policy may guide the policymaker's choice of the most effective instruments. This was one of the major motivations for the current study. Therefore, this study tries to look into the policy design for the promotion of broadband penetration.

The purpose of this research is to examine, both theoretically and empirically, the effect of public policy on broadband development. This study analyzed the policy factors promoting fixed broadband penetration in 30 OECD countries.

This dissertation consists of six chapters. Chapter one is the introduction. Chapter two provides a literature review on the determinants of fixed broadband penetration and an in-depth examination of previous studies on the policy factors of fixed broadband penetration. Chapter three investigates the benefit and limitations of public policy. Chapter four provides a detailed research on public policy through four case studies. The empirical analysis is conducted and results are presented in chapter five. Chapter six discusses the policy implications based on the empirical results. The study ends with our conclusions and future research possibilities.

Chapter 2 Literature review on factors of broadband penetration

2.1. Overview

The purpose of this research is to analyze the impact of public policies on broadband services penetration. A number of opinions have been expressed and discussions held regarding the determinants of broadband penetration. The level of broadband development and growth rate of broadband penetration are complex outcomes of many complementary factors, ranging from socioeconomic determinants (not only income, location, education, family size, individuals' characteristics but also market structure, technological endowments, and other factors) and regulatory actions (indirect policy) to non-regulatory interventions (direct public policy interventions) (Figure 2.1). Indirect policies refer to the policy measures which are able to make contribution to create an investment-friendly regulatory environment in the form of regulatory interventions, and direct policies are interventions in the form of actions more akin to the domain of industrial policies (Belloc et. al., 2012, p. 385). We discuss the direct policies in detail in chapter three.

Socioeconomic drivers (i.e., demand-side determinants) of broadband adoption have been highlighted in several studies addressing three main issues: adoption and usage (Flamm and Chaudhuri, 2007; Rappoport et al., 2003; GAO, 2006), rural–urban digital divide (Preston et al., 2007), and medium adoption (interaction between fixed and mobile broadband) (Bohlin

and Westlund, 2008; Hauge et al., 2009). With respect to regulatory factors, Cambini and Jiang (2009) provide a comprehensive literature review of broadband investment and regulation. This chapter focuses on non-regulatory factors, that is, the direct forms of public policy interventions in broadband diffusion.

Worldwide, countries have been pursuing public policies to promote broadband penetration and upgrade of existing networks (e.g., the ambitious National Broadband Network, or NBN, in Australia). However, the performance of these policies remains to be fully examined. Only a handful of studies have specifically investigated the effectiveness of public policies for broadband promotion, and their conclusions are inconsistent. Furthermore, most of these are qualitative studies; empirical research is rare. Thus, this chapter further examines the effectiveness of direct public policies and the process of broadband diffusion. Section 2.2 discusses socioeconomic factors, while section 2.3 deals with industry factors and regulation. Since the purpose of this research is to analyze the policy factors of broadband services penetration, section 2.4 provides an in-depth survey of the literature on policy factors.

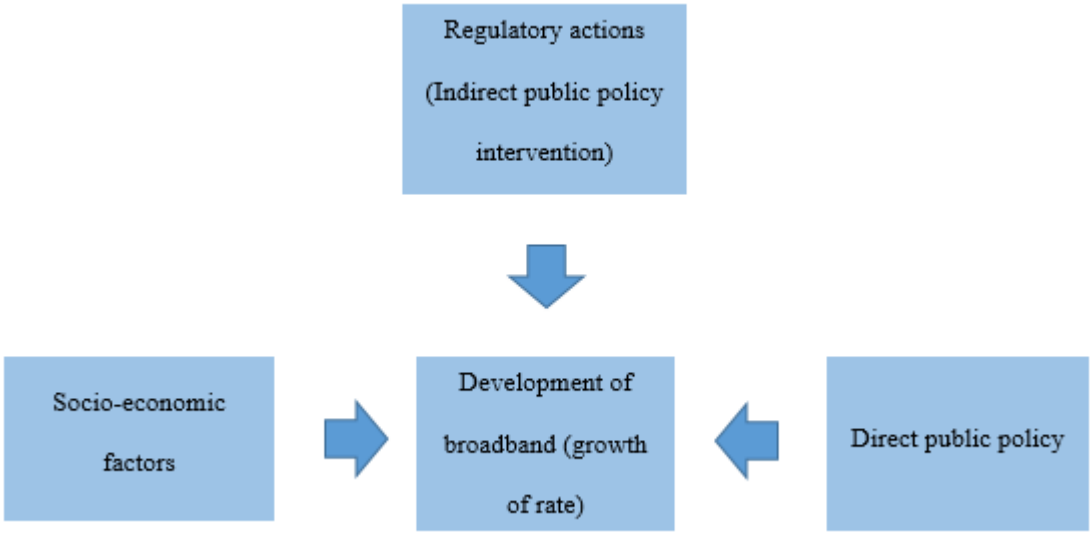

Figure 2.1 Factors influencing development of broadband

2.2. Socioeconomic factors

Many papers have highlighted the critical determinants of broadband adoption differences. A general consensus reached by these studies is that age, income, education, urbanization, and population density are strongly correlated to broadband adoption.

In some multi-country analyses, Bauer et al. (2003) suggested that the preparedness[3] of a

[3] In this paper, preparedness is interpreted as a measure of the attitudes of a population toward information technology as well as its savvy to use it. The Mobile/Internet Index (calculated by the ITU) is used as a proxy for this variable. "The Mobile/Internet Index measures how developed each economy is in terms of information and communications technologies while also capturing how poised it is to take advantage of future ICT advancements. The Index has 26 variables sorted into three clusters: infrastructure, usage, and market structure" (ITU, 2002, p. A-68). The 26 variables are: Infrastructure (Fixed lines per 100 inhabitants, Mobile cellular subscribers per 100 inhabitants, Estimated Internet users per 100 inhabitants, Personal computers per 100 inhabitants, International Internet bandwidth (Mbit/s), Broadband subscribers per 100 inhabitants, Number of leased lines in the country in Dec of the year, Does the economy have a 2.5G mobile network in operation? Has the economy licensed 3G? Does the economy have a 3G mobile network in operation?), Network usage (Roaming agreements based on main operator, Number of ISPs in the country, Number of servers using SSL encryption > 40 bits, Mobile cost basket, Internet cost basket, Telecom revenue

nation and population density, which affect the cost of deploying network infrastructure, are the most consistent factors explaining broadband adoption in OECD countries. Grosso (2006) found that income is related to broadband penetration among OECD countries. Similar conclusions are reached by Wallsten (2006), who found that income and urbanization are factors of broadband adoption in OECD countries. In an empirical study, Turner (2006) showed that poverty rate and income are influential factors of broadband deployment. Atkinson et al. (2008) found that age is negatively correlated to broadband adoption in OECD countries—that is, younger age is associated with a higher level of broadband adoption. In addition, Trkman et al. (2008) showed that population density and education are significant demographic factors that explain fixed broadband deployment in EU countries.

Other studies have focused on individual countries or regions, analyzing the factors of broadband adoption on the basis of survey data. Chaudhuri et al. (2005) found that income and education strongly influence broadband deployment in the United States. Similarly, the United States Government Accountability Office (GAO) (2006) reported that consumers with high incomes and college degrees are more likely to adopt fixed broadband services.

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as a percentage of GDP), Market conditions (Is the incumbent public or private? For how many years has the incumbent been private? Is there a separate regulator? For how many years has the regulator been separate? What is the market structure for local service? What is the market structure for long distance? What is the market structure for international calls? What is the market structure for cellular? What is the market structure for leased lines? What is the market structure for Internet service providers?) (ITU, 2002, p. A-71).

Moreover, a household-level analysis in Clements and Abramowitz (2006) found that income, age, and educational attainment are critical factors of broadband adoption in the United States. Besides, an empirical study by Lee (2006), applying data from 50 states in the United States, suggested that income has a significant impact on broadband deployment in the United States.

2.3. Regulatory factors

As regards industry factors of broadband penetration, a few studies argue that the availability of different broadband platforms, market competition (inter-platform and intra-platform competition[4]), teledensity[5], and price are significant factors influencing broadband penetration.

A number of multi-country studies have investigated the industry factors of broadband penetration. Garcia-Murillo (2005) found that the price of fixed broadband, income, and competition have significant influences on fixed broadband adoption. Using data on 14 European countries, Distaso et al. (2006) suggested that inter-platform competition drives broadband adoption, but that competition in the digital subscriber line (DSL) market does not have a significant impact on the adoption rate. Grosso (2006) found that competition

[4] Inter-platform competition (also called facilities-based competition or infrastructure-based competition) occurs when an entrant firm builds its own broadband network. Intra-platform competition (also called service-based competition) results when the entrant makes use of the incumbent's network.

[5] Teledensity refers to the number of telephone lines per square mile.

and local loop unbundling (LLU)[6] influence broadband adoption among OECD countries. In addition, Fransman (2006) found that disruptive competitors[7] is significant determinant of global broadband performance. Similarly, Lee and Brown (2008) found that information and communications technology (ICT) infrastructure is a significant factor in broadband adoption. In a multi-country study, Wallsten (2006) suggested that telecommunication density is a factor of broadband adoption in OECD countries.

In a study focused on individual countries, Aron and Burnstein (2003), using US data for 2000, suggest that inter-platform competition is associated with increased household subscription to broadband service. Similar conclusions are reached by Lee (2006), who found that inter-platform competition and availability of various broadband platforms have influenced broadband penetration in the United States. In another panel data analysis, Denni and Gruber (2005) showed that inter- and intra-platform competition in the DSL market and telecommunication density[8] have positive impacts on broadband penetration in the United States.

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[6] LLU is the process in which incumbent operators make their local networks available to other companies.

[7] "Disruptive competition" is said to exist when competitors of the incumbent are so aggressive with their pricing that they do not even cover their marginal costs in the market and end up making short-run losses (Fransman, 2006, p. 24).

[8] Telecommunications density can be explained as follows: "For DSL technology to be viable the length of the local loop, which is the distance between the subscriber and the so-called central office, should not be too large, normally within the range of a few kilometers. Thus the more central offices a state has, the more it is amenable to supplying broadband access. This density may be indicated by the ratio between the number of lines and the number of central offices" (Denni and Gruber, 2005).

A few studies have investigated the influential factors of broadband penetration. Table 2.1 lists the important empirical studies on the factors of fixed broadband penetration. All the variables identified in those studies can be categorized into three groups: socioeconomic factors, regulatory factors, and direct public policy factors (see Figure 2.1). We find socioeconomic factors and regulatory factors are approved as significant factors of broadband penetration. However, we find there are few empirical studies which look into the direct public policy factors, which is considered to have critical influence on broadband penetration. This suggests the significance of this research. Thus, in order to fill this research gap, this study conducts empirical analysis on direct public policy factors.

Table 2.1 List of previous empirical studies on fixed broadband penetration factors[1]

Authors	Study areas	Data collection period	Method	Targeted industries	Findings						
					LLU.[2]	Price	Com.[3]	Inc.[4]	PopD.[5]	Urb.[6]	Others
Bauer et al. (2002)	16 European and American countries	1996, 1998, 2000	Cross-country panel regression model	Cable modem	+[7]	−[8]					PC-penetration[9]
Aron and Burnstein (2003)	U.S. states	2000	Cross-section of state level regression model	Cable modem, DSL			+				
Bauer et al. (2003)	30 OECD countries	2001	Cross-country regression model	Cable modem, DSL					+		Preparedness of a nation[10]
Distaso et al. (2006)	14 European countries	2000–2004	Cross-country panel regression model	Cable modem, DSL, FTTx		−	+				
Wallsten (2005)	U.S. states	-2005	Cross-section of state level panel regression model	Cable modem, DSL	+						Subsidies[11] Access to public rights-of-way[12] Using universal service mechanisms[13]
Cave-Ferreruela and Alabau-Munoz (2006)	30 OECD countries	2000–2002	Cross-country panel regression model	Cable modem, DSL			+	+			Internet penetration[14] Broadband coverage Economic level[15] Education level[16]
Grosso (2006)	30 OECD countries	1999–2005	Cross-country panel regression model	Cable modem, DSL	+		+	+			
Turner (2006)	30 OECD countries	2005	Cross-country model	Cable modem,				+			Poverty rate[17]

Authors	Study areas	Data collection period	Method	Targeted industries	Findings						
					LLU.[2]	Price	Com.[3]	Inc.[4]	PopD.[5]	Urb.[6]	Others
				DSL							
Wallsten (2006)	30 OECD countries	1999–2003	Cross-country panel regression model	Cable modem, DSL, FTTx	—[18]			+	+		Teledensity[19]
Hoffler (2007)	16 western European countries	2000–2004	Cross-country panel regression model	Cable modem, DSL	+		+				
Ridder (2007)	30 OECD countries	2005	Cross-country regression model	Cable modem, DSL		−				+	Age Saturation[20]
Atkinson et al. (2008)	30 OECD countries	2007	Cross-country regression model	Cable modem, DSL		−		+		+	Internet users, Median age
Lee (2008)	30 OECD countries	2001–2008	Cross-country panel regression model	Cable modem, DSL		−	+				Political freedom[21], Mobile price, Previous penetration, Internet use, Bandwidth
Belloc et al. (2009)	21 OECD countries	2006(2007)	Cross-country regression model	DSL				+			Demand policies, Anti-monopoly policies[22], Availability of venture capital[23], Quality of electricity supply[24], Number of internet hosts, Education
Bouckaert et al. (2010)	20 OECD countries	2003–2008	Cross-country panel regression model	Cable modem, DSL		−	+	+	+		PC-penetration
Ford et al. (2011)	30 OECD countries	December 2006, June 2007, December 2007	Cross-country pooled regression model and stochastic frontier analysis	Cable modem, DSL, FTTx		−					GDP per capita, GINI index, Age, Wireline telephones per capita

Authors	Study areas	Data collection period	Method	Targeted industries	Findings						
					LLU.[2]	Price	Com.[3]	Inc.[4]	PopD.[5]	Urb.[6]	Others
Gulati and Yates (2012)	38 technologically advanced countries 75 technologically developing countries	2008	Cross-country regression model	Cable modem, DSL, FTTx						+	Telecommunications investment index, Government effectiveness, Education, Telecommunications competition index, National regulatory authority for telecommunications, Democratic political structure[25], GDP per capita, Income inequality
Belloc et al. (2012)	30 OECD countries	1995–2010	Cross-country panel regression model	Cable modem, DSL, FTTx			+				Implementation of long-term loans programs for broadband suppliers and national financing programs, the creation of public-private partnerships, Initiatives of public demand of specific services, the provision of incentives to business or private demand, the provision of demand subsidies, the adoption of demand aggregation policies, technological competition, market competition, the number of internet subscribers and users, level of legal

Authors	Study areas	Data collection period	Method	Targeted industries	Findings						
					LLU.[2]	Price	Com.[3]	Inc.[4]	PopD.[5]	Urb.[6]	Others
											liberalization, level of unemployment, age, female population, education.
Kyriakidou et al. (2013)	26 European countries	2001–2009	Cross-country panel regression model	Cable modem, DSL, FTTx					+		E-government online availability, Communication expenditures, PC-penetration, Internet skills[26]

Note 1: In the table, the variable are significant at least at 10% level.
Note 2: Local loop unbundling is the process where the incumbent operators makes its local network available to other companies.
Note 3: Facilities-based competition is the competition among platforms with different or same technologies such as digital subscriber line and cable modem.
Note 4: Income is measured by GDP per capita, based on both exchange rates and on purchasing power parities.
Note 5: Population density is measured by number of people per square km.
Note 6: Urban population refers to people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects.
Note 7: Plus in the table means the variable has positive influence on broadband penetration.
Note 8: Minus in the table means the variable has negative influence on broadband penetration.
Note 9: The number of Internet hosts and Internet users.
Note 10: Preparedness is interpreted as a measure of the attitudes of a population towards information technology as well as its savvy to use it, Mobile/Internet index (calculated by the ITU) is used as a proxy for this variable. "The Mobile/Internet Index measures how developed each economy is in terms of information and communications technologies while also capturing how poised it is to take advantage of future ICT advancements. The Index has 26 variables sorted into three clusters: infrastructure, usage, and market structure" (ITU, 2002, p. A-68).
Note 11: Only subsidies from USDA's broader telecommunications program have positive impact on broadband penetration.
Note 12: Guaranteed access to public rights-of-way is correlated with increases in broadband penetration.
Note 13: The research found that universal service programs have negative impact on broadband penetration.
Note 14: It is measured by the percentage of dial-up Internet subscribers, which is found have positive impact on broadband penetration.
Note 15: Economic level is represented by the gross national income (GNI).
Note 16: Education level is measured by the percentage of population with a tertiary education.
Note 17: The share of individuals with equivalised disposable income less than 50 percent of the median for the entire population.
Note 18: It is found the larger the share of telephone lines in a state provided under the unbundling regulations, the slower the rollout of broadband. However, the share of lines provided by competitive local exchange carriers under total service resale is positively correlated with broadband penetration.
Note 19: Ibid. footnote 8.
Note 20: There are four measures of measures of saturation: Internet penetration, the ratio of broadband penetration at Dem. 2005 to Dem. 2004, the share of total internet subscribers accounted for by broadband, fixed telephone density.
Note 21: Political freedom is measured by the inverse of the score on civil liberties.
Note 22: Effectiveness of antimonopoly policy is dummy, measured by the index provided by the Global Competitiveness Report. A dummy variable equals 0 if the antimonopoly policy is lax and not effecting at promoting competition, and 1 if the antimonopoly policy is effective and promotes competition.

Note 23: Venture capital variable is measured by two indicators (venture capital investments in communications as a percentage of all venture capital investment in a given country, and the venture capital investments in communications in a given country as a percentage of all venture capital investment).
Note 24: This variable is used in order to measure the quality of the infrastructures needed for broadband Internet connections.
Note 25: The Unified Democracy Score for 2007 is used to measure the impact of political structure and a culture of democratic politics.
Note 26: Individuals' level of Internet skills is measured by percentage of the total number of individuals aged 16 to 74.

2.4. Direct public policy factors

Numerous studies have shown the social and economic benefits of broadband infrastructure (Ford and Koutsk, 2005; Lee et al., 2005). Broadband has the potential to improve a nation's quality of health services, education levels, connectedness of its government with the public, employment opportunities, and prosperity (Firth and Mellor, 2005). Some of the activities enabled by broadband include distance healthcare, education, social relations, and entertainment; its immediate benefits include e-learning, e-government, tele-medicine (e.g., tele-radiology), creation of Internet communities, and online gaming (Majumdar et al., 2010, p. 649). Consequently, countries worldwide have been undertaking public policies to increase broadband penetration and to upgrade existing networks. However, many studies have focused on broadband infrastructure in regions, laying particular emphasis on either availability or regulations—that is, the supply-side issues of broadband (Preston et al., 2007; Falch and Henten, 2010). Fewer studies consider direct public policies and broadband demand (Firth and Mellor, 2005; Teppayayon and Bohlin, 2009; Hauge and Prieger, 2010). As such, more attention should be paid to the influence of direct public policy. I now provide an in-depth review of the existing literature on direct public intervention in the promotion of broadband.

2.4.1. The rationale for direct public intervention

Historically, the state has played a leading role in the electronic communications sector in most countries, with the telecommunications infrastructure being developed and managed by state-owned organizations in a legal monopoly regime. However, since the second half of the 1980s, the process of liberalization and privatization has affected the electronic communications sector in many countries (Belloc et al., 2012), starting with a reduction in the role of the state. This role reduction is mainly attributed to the governments' realization of two major problems with the operations of the regulated service-providing monopolies: (1) Service was relatively poor, and it did not improve at the pace of technological advance made in these industries. (2) Regulators failed to control prices and other charges levied on consumers (Shy, 2001, p. 7). Against this background, where attention was focused primarily on opening up the market, a consensus favored the idea that infrastructure financing should be entrusted entirely to the market. Direct public intervention was ruled out, and the role of policymakers was limited to regulatory actions designed by independent regulatory authorities supervising firms with significant market power. This view was dominant until a few years ago, implying that broadband emerged in an environment of competition rather than monopoly and that every broadband provider has from the beginning faced actual or imminent competition. However, the view (elimination of government intervention) is now evolving again (Cave and Martin, 2010). The high cost of

broadband line construction and the low propensity of providers to invest in rural and peripheral areas have once again placed the issue of financing telecommunications networks in the hands of policymakers.

In short, when broadband has been targeted, policies seem to step back to the first era of the telecommunications market, characterized by government domination. Thus, the debate focuses not on whether public players should intervene but, instead, on how their interventions should be designed and implemented.

2.4.2. Categorizations of direct public policy

A wide range of policy tools has been adopted in the promotion of broadband. There are also a number of categorizations of the forms of policy interventions available to governments for broadband promotion.

A 2011 study by the Florence School of Regulation (FSR) categorized the supply-side policy tools according to their primary objective, distinguishing between (1) policies aimed at reducing private operators' costs of deployment, including rule-making, fiscal incentives, and long-term loans; (2) policies aimed at enhancing private operators' access to the market, comprising spectrum policies and territorial mapping; and (3) interventions that involve the direct development of broadband infrastructures by public bodies, including investment in the construction of backbone network, creation of a public information infrastructure, and provision of broadband services through municipal utilities. The demand-side policy tools

are categorized into (1) policies aimed at increasing the perceived value of broadband services and (2) policies aimed at reducing the cost of access to broadband service, including targeted subsidy/tax reductions, demand measurement, and demand aggregation policies[9].

A study by the World Bank proposes that broadband be viewed as an interconnected, multilayered "ecosystem" that includes its networks, the services that the networks carry, the applications they deliver, and users (Kim et. al., 2010). Each of these elements depends on high-speed connectivity and has been transformed by technological, business, and market developments.

Another key framework is proposed by King et al. (1994). The researchers used institutional theory to examine government intervention in ICT diffusion. Their model is constructed on two dimensions of potential institutional action: influence and regulation with which institutions might exert supply-push and demand-pull forces, providing a context for government actions. They claim that government intervention can be either influential or regulatory. Influence is the persuasive power that an institution imposes on the practices, rules, and belief systems of those under its sway. Regulation is direct or indirect intervention in the behavior of those under the institution's influence. Under supply push, intervention concentrates on stimulating the production and application of the innovative

[9] Schemes aimed at coordinating the potential demand of consumers in order to ensure efficient resource allocation and obtainment of economies of scale.

product or process itself. Under demand pull, interventions focus on mobilizing acquisition of the potential demand of the innovative product. The researchers classified these actions into six general kinds: knowledge building, knowledge deployment, subsidy, mobilization, standard setting, and innovation directive. Based on the framework they provided, Choudrie and Papazafeiropoulou (2006) examine the institutional actions taken by the South Korea government and finds that the aggressive broadband diffusion strategy of the Korean government was phenomenally successful, leading to the deployment of a heavy regulatory framework and support for demand-pull forces. A later study (Choudrie and Papazafeiropoulou, 2007), incorporated a time dimension into the same framework and found that there was a move from influential, supply-push strategies that allowed competition to lead the market to more aggressive, demand-pull policies that allowed stronger regulation development in broadband policies in the UK. This change in approach is mainly attributed to the fact that as the government's goal had remained unapproachable with the broadband penetration being relatively low under the initial strategies, the government looked at developing educational programs that enforced the demand-pull policies while also considering regulation of vendors.

Trkman and Turk (2009) expand on the main framework of King et al. (1994). In this approach, instead of distributing actions into influence and regulation, first, the supply and demand sides are distributed into social and economic activities; next, the actions are

distributed based on their influencing factors, namely, enablers and means, usage of information services, and ICT sector environment.

The above literature highlights that public policies generally fall into one of two groups: supply-side policies that primarily intend to increase broadband deployment and demand-side policies that largely work to promote broadband penetration. Thus, in order to examine the transition of direct public policies, according to the targets of a certain program, this study reviews the main forms of these interventions. Since this study focuses on direct public policy of fixed broadband, regulatory measures and the wireless broadband market will not be covered.

2.4.3. Influence of direct public policy

The first category of existing studies on the influence of direct public intervention focuses on whether public policy has significant influence on broadband penetration; their results are inconsistent. An empirical study by Bauer et al. (2003), analyzing 2001 data on 30 OECD countries, shows that variables related to public intervention are not statistically significant. Furthermore, Aizu (2002) reports, through a more qualitative comparative research of broadband diffusion in Asia, that government policies do not have much influence in promoting broadband use. In contrast, a qualitative study by Troulos and Maglaris (2011) find an optimistic conclusion on the influence of public policies. In addition, a comparative study on broadband policy among EU countries by Bohlin and

Teppayayon (2010) suggest that public intervention can be an effective tool under certain conditions.

The second category of studies concentrates on how the intervention should be implemented. A case study by Youtie et al. (2007) finds that a combination of demand- and supply-side interventions leads to more effective results than adopting only supply-side measures, because network availability per se does not stimulate demand, and emphasizes the indispensability of demand-side policies to stimulate broadband penetration. Similar conclusions are reached by Troulos and Maglaris (2011). Furthermore, the literature on network effects (Katz and Shapiro, 1994) concludes that the mere availability of broadband connections, ensured through supply-side polices, may not be sufficient to stimulate effective penetration. Shim et al. (2006) find that both Sweden and South Korea have experienced successful interventions (Sweden and South Korea are the top leaders among OECD countries in Broadband penetration) and share a commitment to demand-side intervention, robust competition, and other supply-side factors while each has exhibited different approaches. Hauge and Priedger (2010) point out that demand-side policies aimed at increasing potential subscribers' perceived value of broadband and/or decreasing the cost of access to broadband connections may help ensure broadband adoption. A later qualitative study by Belloc et al. (2012), covering 30 OECD countries over the period 1995–2010, shows 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.

In fact, the sequence with which supply- and demand-side policies are adopted has captured researchers' attention. The econometric model in Belloc et al. (2012) finds that effectiveness is greatest when supply-side policies come first and demand-side policies follow. Moreover, when infrastructure is underdeveloped, investing in demand-side policies is likely to be useless. In contrast, Choudrie and Papazafeiropoulou (2007) find that, as the broadband market matures, the Korean government is moving from a regulatory demand-pull strategy to a less-assertive policy approach focusing on supply push. That means the Korean case, which is regarded as the best practice, seems to go against the results of the empirical research.

We find no consistent conclusion about either the influence of public policy or the different effects of supply- and demand-side policies. This suggests the significance of this research. Thus, in order to fill this research gap, this study has two main objectives. It re-examines the direct public policies of the UK, Sweden, South Korea, and Australia, working under the assumption that direct public policies, targeting both the supply and demand sides, can positively affect broadband penetration. Furthermore, it discusses the question whether the incentive for broadband penetration likely results from a demand constraint or a supply constraint.

Table 2.2 Literature on analysis of direct public policy with regard to broadband penetration and the main results

Authors	Targeted nation/area	Method	Main focus	Main results
Aizu (2002)	Korea, Singapore, and Japan	Comparative study	Analysis of factors that influenced broadband development	Level of economy is not the most significant factor to determine broadband development, nor does government policy to promote broadband have much influence. Social factors, political situation, people's mentality, and cultural context play more critical roles than economy and public policy.
Grubesic and Murray (2002)	Franklin County in Central Ohio, US	Case study	Analysis of the impact of local geography on broadband network access	Broadband penetration depends on a complex dynamic interplay between geography, socioeconomic status, and market forces.
Bauer et al. (2003)	30 OECD countries Data: 2001	Empirical study	Analysis of the influence of important economic and policy variables on the diffusion patterns of broadband	The preparedness of a nation and the cost conditions of deploying advanced networks are the most consistent factors explaining broadband penetration. The price of broadband, the price of dial-up service, competition, and income are either less or not significant. Parameter estimates of variables related to public intervention are not statistically significant.
Grubesic (2003)	Franklin County in Central Ohio, US	Case study	Exploration of broadband access option in the state of Ohio, US, by examining the characteristics of market demand driving cable and DSL infrastructure investment	Federal policy has a significant impact on the location of infrastructure investment. Income, education, age, location, and competition from alternative broadband platforms influence DSL infrastructure investment.
Hollifield and Donnermeyer (2003)	US Department of Commerce Data: 1998	Empirical study	Analysis of variables that influenced rural residents' comparatively early adoption of information technologies at a time when the rural-urban digital divide in the use of basic online services was still growing	Rural development specialists should focus on encouraging locally owned rural businesses to adopt information technologies as a means of maximizing local diffusion and increasing demand levels.
Prieger (2003)	US data at the area level from 2000	Empirical study	Analysis of the correlation between socioeconomic factors and the availability of broadband access	Little evidence of unequal availability based on income or on black or Hispanic concentration. Broadband availability increases with market size, education, Spanish language use, and Bell presence.
Grubesic (2004)	FCC Form Data: 1999 to 2002	Empirical study	Analysis of geodemographic factors on broadband access and availability	Broadband availability is no longer simply a question of geography. Instead, there exists a complex and dynamic interplay between geography, socioeconomic status, market forces, and policy, all of which shape the current broadband landscape.

Authors	Targeted nation/area	Method	Main focus	Main results
Garcia-Murillo and Gabel (2005)	100 countries Data: 2001	Empirical study	Exploration of factors that affect broadband access and number of subscribers	GDP per capita, population size, price, competition, and percentage of dial-up Internet users and hosts all have positive effects on broadband penetration. Policy to be implemented to promote broadband should foster competition through unbundling and/or reduced price.
Cava-Ferreruela and Alabau-Munoz (2006)	30 OECD countries	Empirical study	Analysis of the effectiveness of different policy choices to promote broadband and factors influencing broadband supply, demand, and adoption	Technological competition plus low cost of deploying infrastructures and predisposition to use new technologies appear to be key drivers of broadband supply and demand, respectively. Policies aimed at fostering theses drivers seem to be the most effective.
Tookey et al. (2006)	Scotland	Case study	Analysis of policies and initiatives used to encourage broadband awareness, availability, and adoption in remote and rural Scotland	Broadband availability does not lead to its adoption. National initiatives designed to raise awareness of broadband are not perfectly aligned with initiatives that are solely focused on rural and remote Scotland.
Youtie et al. (2007)	LaGrange, Georgia (US)	Case study	Examination of the use of supply-side strategies	Supply-side policies and initiatives work well for people who are already predisposed to use the technology. In order to realize substantive economic development outcomes of supply-side investment, there has to be investment in building demand.
Grubesic (2008)	US data Data: 1999 to 2004	Empirical study	Exploration of spatially unbalanced levels of broadband provision in the US	Much of the geographic variation in broadband availability can be explained using a select set of demand-side determinants. Supply-side determinants are also critical in explaining the diffusion, adoption, and availability of broadband; metropolitan size is not the only factor that determines the availability of broadband.
LaRose et al. (2011)	4 geographically and demographically diverse rural counties (US)	Case study	Analysis of the impact of federal broadband grants on broadband penetration in rural communities	State-funded public education campaigns can increase broadband awareness and adoption as well as perceptions of the benefits of broadband service.
Sunada et al. (2011)	Japan	Case study	Analysis of the diffusion process of Internet broadband access in Japan by modeling the household choice of access modes	The characteristics of users, rather than access modes, play a significant role in demand substitution across modes. Demand-side conditions of broadband access could change drastically because of technological development and evolution of complementary markets that make the Internet more attractive and enhance indirect network effects.
Troulos and	European countries	Case study	Analysis of factors that determine municipal strategies in fixed next-	Municipal initiatives are highly dependent on national factors. Current EU provisions for public involvement in broadband

Authors	Targeted nation/area	Method	Main focus	Main results
Maglaris (2011)			generation access networks	development stimulate municipal plans for large-scale arrangements. National regulatory frameworks, which primarily address vertical integrated incumbents and nationwide markets, need adjustments to handle emerging access monopolies of regional and city broadband infrastructures.
Belloc et al. (2012)	30 OECD countries Data: 1995 to 2010	Empirical study	Analysis of the impact of a vast array of public policies on wireline broadband penetration	Both supply- and demand-side policies have a positive effect on broadband penetration, and their relative impact depends on the actual stage of broadband diffusion. Broadband adoption rates increase with the share of the service sector in the economy, number of mobile subscriptions, and degree of market competition.

Source: The author

2.5. Summary

This chapter provides a literature survey on the factors of broadband services, which focuses on the socioeconomic drivers of broadband penetration, the interplay between industry factors and regulation, and policy factors. It is found that public policies generally fall into two groups: policies that primarily intend to increase broadband deployment and policies that largely work to promote broadband penetration. While only a handful of studies have specifically investigated the effectiveness of public policies for broadband promotion, their conclusions are inconsistent. Besides, most of these are qualitative studies; empirical research is rare. This study aims to fill this research gay by investigating, both theoretically and empirically, the impact of public policies on broadband penetration.

Chapter 3 Analytical framework

3.1. Overview

In chapter two, we reviewed the literature on the determinants of broadband penetration, particularly the policy factors. Policies are made by government authorities. This chapter investigates the telecommunications market failure and discusses the rationale for government intervention in detail in section 3.2. An analytical framework is then presented in section 3.3 to clarify the policy. Section 3.4 provides an in-depth discussion on the effects and limitations of supply- and demand side policies.

3.2. Market failure and government intervention

Considering the critical importance of broadband for business activities and economic growth, many nations have committed resources for the development of broadband technology, stimulating private investment.

In the telecommunications industry, the main reasons for government interventions are natural monopoly situations, universal service reasons, and network externalities (Faulhaber and Hogendorn, 2000, p. 307). Telecommunications markets were born of natural monopolies because of high fixed cost[10]. Such networks constitute a natural monopoly for

[10] A natural monopoly has a high fixed cost for a product, and its marginal cost of producing one more good is small (Varian, 2006, p.435).

which competition is not feasible, and market intervention is therefore necessary to control monopoly power. Universal service is also considered an equity motive for public investment (Cave and Martin, 2010). Governments impose universal service obligations on incumbent operators to expand service coverage to rural areas seen as unattractive regions in order to achieve universal service, where all citizens have low-cost access to the network. The operator finances the provision of telecommunications services to unprofitable areas by cross-subsidies.

The third reason is the positive externalities from service adoption. Externality is the divergence between private and social benefit (or cost). "Externalities arise when one market participant affects others without compensation being paid" (Shapiro and Varian, 1998, p. 183). Externalities can be negative or positive. The classic example of a negative externality is pollution[11]. The externalities of the broadband market are positive. Broadband has three kinds of positive externalities: network externalities, competitiveness externalities, and regional externalities. Network externalities are the effects produced on a user of a product by others using the same or a compatible product. Broadband has both direct and indirect network externalities. Direct externalities refer to subscribership: broadband becomes more valuable when more people have broadband access. The indirect network externalities of broadband are its influence on applications and content that require

[11] A company's smoke imposes costs on its neighbors that are not paid for.

broadband transport to work effectively. For example, YouTube took off in 2006 when the broadband user population was large enough to make the business model feasible. Competitiveness externalities arise from the fact that the domestic IT industry becomes competitive in countries leading in broadband. Leadership in broadband generally implies that the country has leading-edge technology buyers. "A nation's firms gain competitive advantage if domestic buyers are among the world's most sophisticated and demanding buyers for a product or service" (Porter, 1990, p. 89). Regional externalities refer to the fact that broadband has become a critical tool in business location and expansion decisions and it is able to boost the quality of life in rural communities, making it easier for rural areas to attract and retain residents.

Positive externalities imply that without government intervention the quantity of the product would be less than economically optimal. Figure 3.1 illustrates a market failure due to positive externalities. In Figure 3.1, D measures the marginal private benefit to the individuals by subscribing to the telecommunications service. MSB is the marginal social benefit to the society. When there are positive externalities, MSB is higher than the marginal private benefits D (Pindyck and Rubinfeld, 2009, p.648). Because of the positive externalities that the telecommunications network creates, the market fails to reach the social optimum equilibrium at point β, where the coverage is Q2, but settles at point α with only Q1 households covered. The inefficiency arises because the broadband users do not

receive all the subscription benefits they pay for. Consequently, the price P1 is too high to encourage them to adopt broadband service at the socially desirable level of coverage. In this case, a lower price, P2, is required to encourage the efficient level of supply, Q2. As a result, the question for the authorities is how to make the supply shift from Q1 to Q2. This may be done in two ways:

- One approach is through the demand side: Users' willingness to pay can be raised by increasing the benefits to individual subscribers, so that the demand curve shifts from D to MSB. Possible measures include improvement of individuals' motivation and digital literacy skills, such as providing more attractive content and lower price.
- The other is through the supply side: Supply can be promoted by lowering the operators' marginal cost, so that the supply curve shifts from MC to MC′. The possible measures include investment subsidies in the form of a tax rebate or direct financial aid.

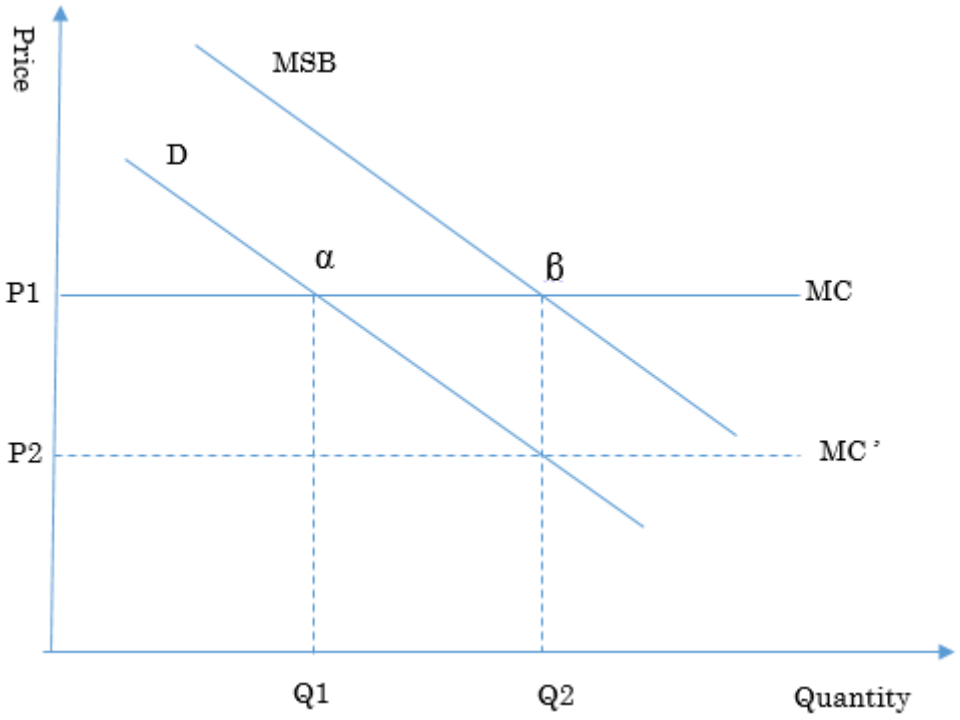

Figure 3.1 Positive externality and market failure

The supply of network infrastructures and demand stimulation used to be intertwined in a complex way. It is believed that the existence of networks tends to promote demand for them; for example, investments in broadband upgrade the general preparedness and appeal to utilize them (Eskelinen et al., 2008). However, Shim et al. (2006) point out that there would be a gap between coverage and adoption when the country only relies on supply-side intervention. Given the crucial importance of broadband for business activities and economic development, precisely understanding whether the public policy initiatives on both the supply and demand sides have been effective in stimulating broadband penetration constitutes a challenge for both researchers and policymakers.

However, government interventions can also have some risks. The main negative impact of government interventions is that they distort competition and duplicate investment and technology obsolescence (Teppayayon and Bohlin, 2009, p. 10). Government intervention could risk causing a disadvantage to commercial companies by deterring private investment, which can reduce the level of competition and innovation. Intervention may result in duplicating investment that has been or would have been made by telecommunications companies. It also has the risk of allocating public investment in equipment that becomes obsolete over time, because the government may choose to deploy a specific technology that is replaced by later market-led development. We discuss in detail the limitations of government interventions in section 3.4.

3.3. Two types of government intervention for broadband penetration

King et al. (1994) propose an approach to examine the government's role in ICT diffusion. In general, "any standing social entity that exerts influence and regulation over other social entities" (King et al., 1994, p. 148)—governments, international agencies (e.g., United Nations, the World Bank), and trade and industry associations, for example—can be defined as an institution. In this article, the researchers have used the demand-pull and supply-push theory in government intervention for technology diffusion, and argued that governments can be either influential or regulatory. They defined supply push as the force that arises from the production of an innovative product or process itself and argued that

"under supply push, intervention must concentrate on stimulating the production and application of factors that go into innovating: a growing supply of scientific and technical knowledge, provision of capital for experimentation and development of prototypes, support for getting innovative products and processes ready for the marketplace, and so on" (King et al., 1994, p. 150). Demand pull is defined as the force that emerges from the willingness of potential users to use the innovation—"under demand–pull, intervention must define and articulate demand to potential sources of supply to innovative action, while mobilizing acquisition of the innovations by users" (King et al., 1994, p. 150). Influence is defined as "the exerting of persuasive control over the practices, rules and belief systems of those under the institution's sway, it is exerted via education and socialization processes of individuals, the systematic articulation of particular points of view (e.g., propaganda), and provision of differentially more resources to those social activities deemed `appropriate` and withholding of resources from those deemed `inappropriate`" (King, et al., 1994, p. 149). Regulation by institutions is "the direct or indirect intervention in behavior of those under the institution's influence, with the specific objective of modifying that behavior through sanction or other affirmative means" (King, et al., 1994, p. 149). Table 3.1 describes this classification in detail, where institutional interventions are classified into four cells.

Relating this to my study, I use King et al.'s framework, utilizing the influence dimension. Specifically, I examine how the UK, South Korea, Sweden, and Australia have

used certain policy measures to diffuse broadband technology.

Table 3.1 Dimensions of institutional intervention

	Supply push	Demand pull
Influence	*Knowledge building* (I-1) Funding of research projects *Knowledge deployment* (I-2) Provision of education services *Subsidy* (I-3) Funding development of prototypes Encouragement of capital markets to support R&D activity Provision of tax benefits for investment in R&D *Innovation directive* (I-4) Direct institutional operation of production facilities for innovation Ⅰ	*Knowledge deployment* (Ⅱ-1) Training programs for individuals and organizations to provide base of skilled talent for use S*ubsidy* (Ⅱ-2) Procurement of innovative products and services Direct or indirect provision of complementarities required for use *Mobilization* (Ⅱ-3) Programs for awareness and promotion Ⅱ
Regulation	Ⅲ *Knowledge deployment* Require education and training of all citizens *Subsidy* Reduction in general liabilities for organizations engaging in innovative activity Modification of legal, administrative, or competitive barriers to innovation and trade *Standard setting* Establishment of standards under which innovative activity might be encouraged *Innovation directive* Establishment of requirements for investment in R&D by organization	Ⅳ *Subsidy* Procurement support for products and processes that facilitate adoption and use *Standards setting* Require particular products or processes to be used in any work for the institution Require conformance with other standards that essentially mandate use of particular products or processes *Innovation directive* Require that specific innovative products or processes be used at all times

Source: King et al., 1994, p. 151

Note: (I-1), (I-2), (I-3), (I-4), (Ⅱ-1), (Ⅱ-2), (Ⅱ-3) are added by the author

Broadband is considered an innovation product, distinct from an invention, which refers to technology actually being used or applied for the first time (Utterback, 1974, p. 621).

In a technological context, the drivers of innovation (i.e., demand-pull factors), whether they arise from market demand or technological shifts, have been universally argued in academic research.

Table 3.2 Definition

Term	Definition
Knowledge building	Financial support for research and development activities of technology.
Knowledge deployment	The dispersion of key concepts and techniques through education or training programs funded by governments.
Subsidies	Subsidies are provided whenever an institution uses its resources to defray the otherwise unavoidable costs and risks to operators and users in process of broadband diffusion in use.
Mobilization	Mobilization basically expresses the intention of the government to make individuals to perceive the potential benefit of broadband and understand the best practice for spurring them to do.
Standard setting	It is a form of regulation aimed at constraining options of decentralized actors and organizations in line with larger social or institutional objectives.
Innovation directive	It is a command to engage in some activity in order to set an example for companies and individuals that tend to use the technology.

Source: Created on the basis of King et al. (1994).

However, the definition used in the technology-push[12] and demand-pull (TPDP) spectrum across the push and pull sides are inconsistent. For instance, at the firm level, demand pull is divided into two types: internal demand pull and external demand pull. Internal demand-pull forces are derived from primary stakeholders, including top management, functional departments, and users who seek innovative opportunities in IT, while external demand pull arises because organizations adopt information technologies in anticipation of positioning themselves in the markets (Drury and Farhoomand, 1999). Furthermore, the understanding

[12] Within the IT literature, supply push is referred to as technological push, created by the advent of new technologies (Drury and Farhoomand, 1999).

of demand pull varies throughout the research even according to the framework proposed by King et al. (1994). One study, from an institutional perspective within the framework proposed by King, examines how government agencies alter the context around production and diffusion of technologies (Lin and Chiasson, 2008). This research defines demand pull as demand that emerges from the provision of resources to support organizational preferences. In other words, the target of demand-side policy is an organization instead of the end user, which is consistent with the study of Drury and Farhoomand (1999). In contrast, Choudrie and Papazafeiropoulou (2007) examine the impact of the UK government's broadband adoption policies using the demand-pull definition in King's paper, whereby demand-side intervention concentrates on driving users' innovation acquisition.

However, this chapter adheres to King et al.'s (1994) description of demand pull as the influence of demand-side forces exerted on a potential broadband subscriber. Thus, demand-side policies refer to policies that aim to increase the willingness of potential users to adopt broadband, while supply-side policies are related to policies that aim to lower the price by providing support to operators. Thus, I describe the interventional actions in broadband diffusion as presented in Tables 3.3 and 3.4.

Public policies are categorized according to the objective of governmental intervention as shown in Tables 3.3 and 3.4.

Table 3.3 Supply-side policies

Objective	Examples	Instrument of technology diffusion
Reducing private operators' costs of deployment	Adoption of fiscal incentive programs and subsidies	Knowledge building (I-1) Subsidy (I-3)
	Administrative simplification initiatives	Innovation directive (I-4)
	Implementation of long-term loan programs for broadband suppliers and national financing programs	Subsidy (I-3)
Enhancing private operators' access to the market	Implementation of territorial mapping programs	Knowledge deployment (I-2)
Direct investment in broadband infrastructures	Investment in construction of backbone network	Subsidy (I-3) Innovation directive (I-4)
	Creation of public information infrastructure	Knowledge deployment (I-2) Innovation directive (I-4) Subsidy (I-3)
	Provision of broadband services through municipal utilities	Knowledge deployment (I-2) Innovation directive (I-4) Subsidy (I-3)

Source: Based on King et al. (1994) and Rossi (2012).

Table 3.4 Demand-side policies

Objective	Examples	Instrument of technology diffusion
Increase value of broadband access (vanquish digital illiteracy and increase the perceived value of broadband for non-adopters)	Increase useful content availability public demand of specific services	Knowledge deployment (Ⅱ-1) Mobilization (Ⅱ-3)
	Increase IT skills	Knowledge deployment (Ⅱ-1)
	Increase awareness	Mobilization (Ⅱ-3)
Reducing cost of broadband subscription	Subsidy and incentives for private and business demand	Subsidy (Ⅱ-2)
	Adoption of demand aggregation policies	Knowledge deployment (Ⅱ-1)

Source: Based on King et al. (1994) and Rossi (2012).

3.4. Failure of government interventions

3.4.1. Asymmetric information

If a decision is made to subsidize operators by lowering the infrastructure cost that companies have to pay and provide incentives to encourage them to increase broadband coverage, we need to seriously consider the asymmetry of information that exists between governments or, say, between regulatory authorities and market players. Governments face asymmetric information about the status of applicants' operations and uncertain demand of potential users. This could lead to loss of public funds, represented in Figure 3.2 as "Loss S." This thesis will discuss the asymmetric information between governments and market players from three aspects.

3.4.1.1. Governments are unable to distinguish areas for broadband networks

Public sector investments are supposed to extend communications infrastructure to areas that are considered unprofitable for private operators; further, these investments should avoid competition distortion. Therefore, public support should be limited to areas where it is not commercially viable for private operators to establish adequate facilities. For example, the European Commission distinguishes between "black," "gray," and "white" areas (Papadias et al., 2006, p. 13). "Black" areas are characterized by the availability of different broadband services over at least two competing infrastructures, where there is a high risk of market distortion if state funding is allowed. "Gray" areas are those where broadband

services are already provided and a more detailed assessment is required before providing state aid. “White” areas are rural and scarcely populated zones, where there are no broadband services or only expensive leased line or satellite services. Public support for broadband in these “white” regions is generally deemed compatible. Thus, the big issue confronting public players is to select areas where state aid would be allowed in the long term, because the supply-side project would take several years to complete. Over this period, some “white” areas could become “gray” or even “black,” considering the speed of development in wireless technologies.

3.4.1.2. Governments are unable to pick the “winning” technology and company

Since high-speed broadband access can be provided through a variety of technologies, such as digital subscriber line (DSL), cable, and wireless networks, governments would be confronting the specific-technology selection problem when they decide to commit public funding to the rollout of broadband infrastructure. In chapter two, I have presented studies showing that competition between different technologies has a significant and positive impact on broadband penetration (Aron and Burnstein, 2003; Distaso et al., 2006; Cava-Ferreruela and Alabau-Munoz, 2006; Hoffler, 2007; Bouckaert et al., 2010). Once state aid is granted to a competitor, potential operators may decide not to enter into the market or existing operators may decide not to enter a certain geographic area. This would distort competition. What is worse, competition distortion is likely to be enhanced if the aid

beneficiary has market power.

It should also be noted that different technologies are associated with different types of actors and there is a possibility of path dependency in the use of technologies by different actors. For instance, incumbent telecommunication operators own public switched telephone networks (PSTN), which is their main strength. Thus, their broadband access strategies would be biased toward DSL (Falch and Henten, 2010). On the other hand, cable companies own cable infrastructures and, therefore, base their broadband access strategies primarily on their cable network. The private partner selection mechanism in a public–private partnership, which is typically how supply-side policies have been widely implemented, may have an enduring influence on the future development of the market (Rossi, 2012). Thus, it is extremely difficult to design the selection mechanism and the rules of public–private interaction such that there is no preference for a specific technology or particular provider.

All the above risks constitute the loss that might be generated in the process of public policies on the supply side (Figure 3.2). However, these policies might work better in the short term as compared to demand-side policies, particularly if access to broadband is not available yet.

3.4.2. Budget constraint of individual household

In contrast, demand-side policies may face the extra loss of involving consumers.

Because of inelastic demand, public programs that aim to raise the consumers' willingness to pay may not directly lead to broadband penetration growth. For instance, some consumers who perceive the usefulness of broadband because of the ICT education program may not subscribe to the broadband service owing to the budget constraint. Moreover, users may not subscribe to the high-speed Internet access service because they are satisfied with the current network service.

Nevertheless, involving consumers in the system means letting market mechanisms do their best, for operators are then selected by the market rather than the public player. In the preceding sections, I have analyzed the risks of supply-side polices. In particular, state aid may reduce competitiveness and reinforce the dominance of an aid beneficiary already dominant on the market. In a monopoly situation, the market is Pareto inefficient because the monopolist produces less than the competitive amount of output and the price will be higher than the competitive level. Thus, "consumers will typically be worse off in an industry organized as a monopoly than in one organized competitively" (Varian, 2006, p. 430).

There are demand-side policies aimed at increasing the demand for the broadband service by raising the perceived value of broadband service. Instead of distorting the market, the measure reduces government interference in the operation of the market and enhances market competitiveness, thereby improving the efficient functioning of the market. We may

suppose that an increase in market demand may stimulate a prospective competitor to set up alternative technologies of broadband connections. Consequently, demand-side policies aiming to increase market demand can promote competitiveness. In addition, several empirical studies have found that inter-platform competition has a significant positive effect on broadband penetration (Aron and Burnstein, 2003; Distaso et al., 2005; Cava-Ferreruela and Alabau-Munoz, 2006; Hoffler, 2007; Bouckaert et al., 2010). An equal division of the market between different technologies (i.e., cable and DSL) leads to a higher level of broadband penetration. This suggests that demand-side policies that promote market competitiveness are able to increase broadband penetration.

Based on the discussion in section 3.4.1. and 3.4.2, we may suppose that demand side policies can be more productive than supply side policies in promoting broadband penetration. When the government make a decision to subsidize operators, there is a loss (Loss S) generated due to the asymmetric information between public players and operators. In contrast, if the governments choose to complement users, leaving the market to choose operators, there are risks of generating a loss (Loss D). Because consumers may remain not subscriber broadband service though awareness to the benefit of broadband is improved.

So it may be supposed once the loss D is less than loss S (or say, if the spending on demand side is less than on supply side), public interventions on demand-side are expected to be more effective than that on supply side. We can say demand side policies are more

productive than supply side policies.

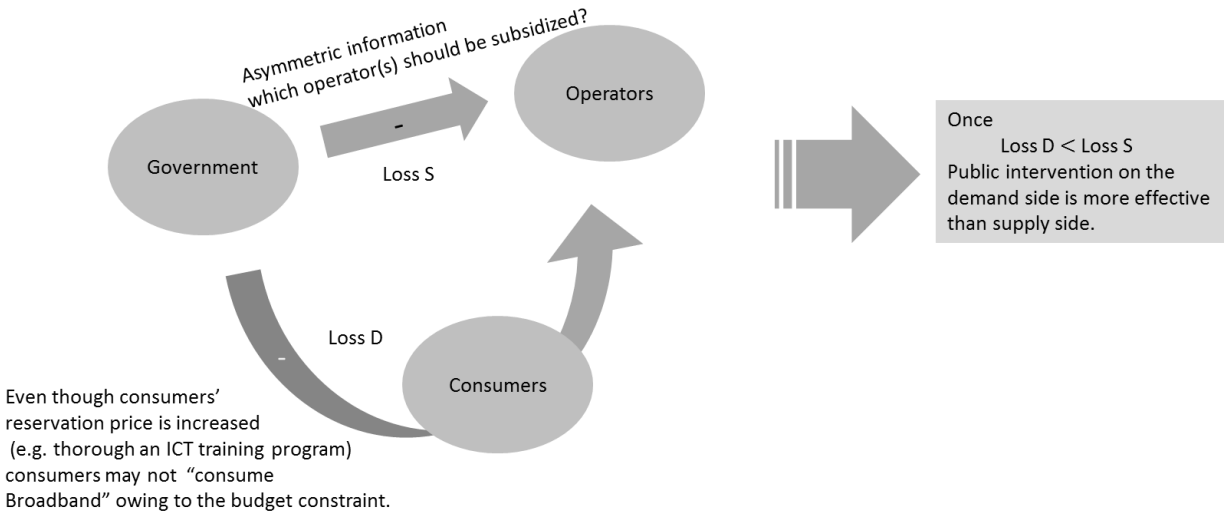

Figure 3.2 How the public player intervenes on the supply and demand side

3.5. Summary

This chapter discusses the advantages and limitations of supply-side policies and demand-side policies. If a decision is made to subsidize operators by lowering the infrastructure cost that companies have to pay and provide incentives to encourage them to increase broadband coverage, we need to seriously consider the asymmetry of information that exists between governments and market players. Governments will be confronted with asymmetric information about the status of applicants' operations and uncertain demand of potential users. In contrast, if the policymakers intend to implement demand-side policies, such as digital training programs to raise people's willingness to pay for broadband, the limitation is that consumers may still not subscribe to the broadband service because of budget constraints. However, the advantage of demand-side policies is that governments can

reduce market distortions by allowing the market mechanisms to function.

Chapter 4 Transition of direct public policy toward broadband

4.1. Overview

Chapter three discuses an analytical framework for innovation diffusion of information and communications technology (ICT).

This chapter, examines the government policies of the UK, Sweden, South Korea, and Australia using the framework developed by King et al. (1994), shown in chapter three, regarding institutional actions for information technology (IT) diffusion.

These four countries are chosen for reasons. All the four countries have developed extensive programs to promoted broadband penetration. South Korea and Sweden have been top performers in broadband. UK is an early leader in reforming telecommunications markets. Compared to these three countries, Australia shows a different propensity for policy interventions. Besides, there are also other constraints that impact on case selection. For instance, available information on the broadband policy of these countries is more exhaustive compared to other OECD countries, detailed information about ICT strategies in France and Japan are available only in French and Japanese, respectively, making the research unfeasible. Therefore, this chapter provides four case studies, followed by a conclusion section on the implementation of direct government interventions in the broadband market in these countries.

4.2. Case studies on broadband policy

The benefits of broadband use have been widely realized, and broadband diffusion has been one of the top items considered in ICT public policies worldwide. Stimulating broadband and ultra-broadband penetration has been a key objective for policymakers in developed as well as less-developed countries.

Although all countries could benefit from using broadband, broadband penetration varies widely among countries (Figure 4.1) (Cheng, 2014b). A number of countries have developed modern broadband networks—allowing for fast and superfast access to information services—but broadband penetration rates remain low compared to its high availability. Given the crucial importance of broadband for business activities and economic development in general (BCDD, 2011, p. 7; Zhao and Ruan, 2009, p. 38), grasping the precise reason broadband connections are still prone to patchy diffusion across countries is a challenging issue for researchers and policymakers. We will review the policies implemented in the UK, Sweden, South Korea, and Australia.

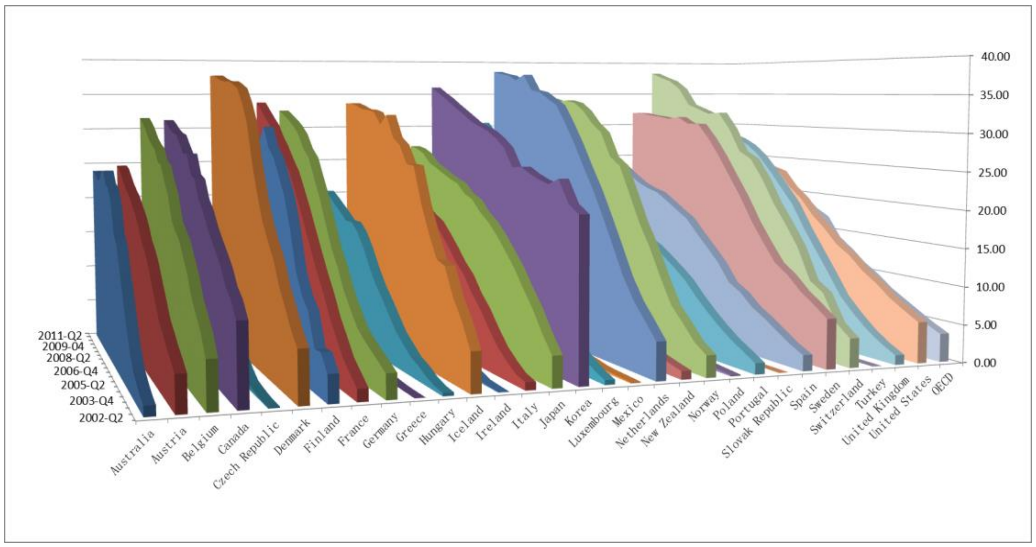

***Figure 4.1* OECD Fixed broadband penetration rates (2002-2011)**

Source: Created on the basis of OECD (2014).

4.2.1. United Kingdom

The UK has a high population density, at 257 people per square kilometer (inhab/km^2) (World Bank, 2012). It also has a highly urbanized population with 80% of the people living in cities[13] (World Bank, 2012). Until 2003, broadband penetration lagged behind the OECD average. By 2004, the figure had increased to 10.2 subscribers per 100 inhabitants, moving ahead of the OECD average (10.1). At 32.7 in 2011, its overall penetration has surpassed that of the previous leaders, Canada (31.8) and Sweden (31.7), while remaining slightly behind South Korea (36.9) (OECD, 2014).

The UK has relied largely on market forces to deploy broadband service, but from a

[13] Urban population refers to people living in urban areas as defined by the national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects.

regulatory perspective, several initiatives have been introduced to promote competition in this arena. For example, between 1998 and 2000, Oftel[14] issued a series of statements setting the terms for wholesale and bitstream access to BT's network; they later expanded the process to encompass local loop unbundling. In 2005, functional separations were imposed on BT between its wholesale inputs business and its retail operations, which were described by Ofcom[15] as one of the key factors leading to greater retail broadband competition in the UK.

In addition to regulatory measures, the UK government has also employed direct interventions in a variety of ways, although direct government investment in infrastructure has remained limited. Table 4.1 outlines the history of these measures.

[14] Britain's first independent telecommunications regulator.

[15] Independent regulator and competition authority for the UK communications industries.

Table 4.1 Public Policies in the UK

Year	Policies examined	Objective	Type of institutional actions
–1999	***UK online centers*** This project was developed in 1999[1]. UK online centers provide access to the Internet, help subscribers use it, and offer training courses for free[2].	Increasing value of broadband access	Demand pull: Knowledge deployment(Ⅱ-1) Mobilization(Ⅱ-3)
2000	***e-government initiative[3]*** The initiative set the goal of making the UK "the most completive e-commerce market in G7 by 2005." The broadband stakeholder group (BSG) was established. The UK Prime Minister pledged one billion pounds for e-government initiatives.	Increasing value of broadband access	Demand pull: Knowledge deployment(Ⅱ-1)
2001	***National broadband strategy*** The UK government established its national broadband strategy in 2001 through its white paper "Opportunity for All In A World of Change" in order "for the UK to have the most extensive and competitive broadband market in the G7 by 2005"[4]. The UK launched its national broadband strategy, 2001-2005, via the Broadband Fund. The UK government provided grants of around $127 million to more than 13 projects, focusing on rural areas.	Increasing broadband penetration by direct investment to broadband infrastructures	Supply push: Subsidy(Ⅰ-3) Innovation directive(Ⅰ-4)
2003	***2003 Broadband Aggregation Project (BAP)[5]*** The project provided more than $2 billion between 2003 and 2006 for broadband connections to primary and secondary schools and other public entities.	Enhancing private operators' access to the market	Supply push: Knowledge deployment(Ⅰ-2)
2004	***e-government*** Directgov[6] was launched by government to allow British citizens to access information from a variety of government agencies. The government intended to provide subsidies for small and medium enterprises in rural areas (via providing grants to small businesses and organizations in remote areas to cover the fee for broadband subscriptions).	Increasing value of broadband access	Demand pull: Knowledge deployment(Ⅱ-1)
2005	***Connecting the UK: The Digital Strategy[7]*** The UK government released its digital strategy focusing on stimulating broadband by promoting virtual learning and universal access to advanced public services, fostering creation of innovative broadband content, providing communal access points and digital literacy programs, and making home PC more affordable. E-learning Foundation leases laptops to parents for four years with a	Enhancing private operators' access to the market Increasing value of broadband access	Supply push and demand pull: Innovation directive(Ⅰ-4) Knowledge deployment(Ⅱ-1)

Year	Policies examined	Objective	Type of institutional actions
	delayed payment scheme.		
2006	***Public and private partnership*** *FiberSpeed*[8] was undertaken. *FibreSpeed* is a high-performance optical fiber network that directly links North Wales to the World Wide Web placing the region squarely onto the digital map of the world. The network is a partnership between private enterprise and the Welsh government.	Reducing private operators' costs of deployment	Supply push: Subsidy (Ⅰ-3)
2009	***Digital Britain***[9] The UK government announced the national broadband strategy "*Digital Britain.*" The strategy proposed initiatives such as providing a favorable climate for investment/innovation in digital content, application, service; developing the nation's digital skills; increasing the quality of public service content; and upgrading wired and wireless infrastructure.	Reducing private operators' costs of deployment Increasing value of broadband access	Supply push and demand pull: Subsidy (Ⅰ-3) Knowledge deployment(Ⅱ-1)
2010	***Public funding*** *Britain's Superfast Broadband Future* is published[10]; the UK government is committed to investing some 530 million pounds of public funds in remote areas and aims to use the public investment to provide a network infrastructure upgrade.	Increasing broadband penetration by direct investment to broadband infrastructures	Supply push: Subsidy (Ⅰ-3) Innovation directive(Ⅰ-4)

Note 1: See the program's description of itself at https://www.ukonlinecentres.com/about-us.
Note 2: See https://www.gov.uk/ukonline-centre-internet-access-computer-training.
Note 3: UK Online Centres and E-Government (see http://www.sqw.co.uk/file_download/55).
Note 4: Department of Trade and Industry, *Review of the UK Broadband Fund* (see http://www.berr.gov.uk/files/file13440.pdf).
Note 5: Broadband Stakeholder Group, *The impact of public sector interventions on broadband in rural areas*, p. 25 (see http://www.broadbanduk.org/wp-content/uploads/2012/11/report03_appendix5.pdf).
Note 6: Directgov, the British government's digital service for people in the United Kingdom, provided a single point of access to public sector information and services. It was replaced, along with the Business Link website, on 17 October 2012 (www.gov.uk).
Note 7: Cabinet Office and Dept. of Trade and Industry (see http://www.naec.org.uk/events/timeline/connecting-the-uk-the-digital-strategy).
Note 8: See http://www.fibrespeed.co.uk/about-fibre-optic-network/.
Note 9: United Kingdom Government, Department for Culture, Media, and Sport and Department for Business, Innovation, and Skills, Digital Britain, Final Report, 2009 (see http://www.culture.gov.uk/images/publications/digitalbritain-finalreport-jun09.pdf).
Note 10: See https://www.gov.uk/government/publications/britains-superfast-broadband-future
.

Table 4.1 shows that the UK government's direct public policies were initially on the demand side, relying largely on market forces to deploy broadband service. Although the UK did establish a national broadband strategy, it has invested considerably less resources in it than Korea, Sweden, or Japan. Direct government investment in infrastructure has been limited. Starting in 2003, the UK government began to implement supply-side policies, when government support projects were initiated and direct investment in broadband infrastructures commenced.

4.2.2. Sweden

Sweden has one of the lowest population densities (23 inhab/km^2) (World Bank, 2002) in Europe, and the majority of its population is clustered in its three major cities of Stockholm, Goteborg, and Malmo. Eighty-five percent of the population lives in urban areas (World Bank, 2012). However, Sweden has one of the highest percentages for broadband Internet availability and penetration, with 32.3 subscribers per 100 inhabitants compared to the average of 25.8 for EU-30 countries (OECD, 2014). Broadband is available in over 99% of households in Sweden (OECD, 2014). High penetration results from well-developed market regulations and broadband strategies.

In 2001, the Swedish regulators, the Post and Telecom Authority (PTS), introduced local loop unbundling in accordance with EU regulations and furthered the initiative, in 2004, by mandating that the incumbent telecommunications company, TeliaSonera, provide bitstream

access for broadband entrants. In 2008, TeliaSonera was required to functionally separate its network and retail services divisions. These measures taken by PTS were quite successful in terms of increasing the numbers of new entrants in the broadband market while decreasing the number of incumbent market shares (PTS, 2007).

In addition to regulatory initiatives, the Swedish government has long been actively involved in rolling out broadband infrastructure through public investment and supporting initiatives that promote demand for broadband access. As early as 1999, the government recommended that the state take action to stimulate broadband rollout in rural and remote areas with no market deployment. In 2000, the Swedish government published its ICT strategy[16], becoming the first European country to implement an active broadband policy. Table 4.2 outlines the history of Sweden's initiatives.

[16]Hall. M. Ministry of Industry, Employment and Communications (see http://www.oecd.org/sti/broadband/33864880.pdf).

Table 4.2 Public Policies in Sweden

Year	Policies examined	Objective	Institutional actions
Since 1960	***e-Government***[1] The Swedish government has 40 year of experience in e-government. It started to have public data stored in digital databases since 1960.	Increasing value of broadband access	Demand pull: Knowledge deployment(Ⅱ-1)
1998	***Tax credits*** In 1998, the Swedish government introduced tax reductions on computers bought by companies for their employees' private usage[2].	Reducing cost of broadband subscription	Demand pull: Subsidy(Ⅱ-2)
2000	***National ICT strategy***[1] The Swedish government published an ICT strategy, *An Information Society for All*, as the first step to implementing a broadband policy. A concerted effort was made to disseminate the broadband agenda to the populace, so that broadband became a well-known term in public life in Sweden. ***Government funding*** The Swedish government committed funds to build an alternative broadband network, and 950 million euros were earmarked for investment to ensure that 98% of all households have a broadband connection by 2005. Financial support was provided by state funds to build backbone networks and regional networks and for expansion of urban networks[3].	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy(Ⅰ-3) Innovation directive(Ⅰ-4)
2002	***Tax reductions*** The government intended to provide tax incentives to telecommunications operators to spur broadband infrastructure building in rural and underserved markets[4]. Tax reductions also were provided to households to install broadband access in the home or apartment.	Reducing cost of broadband subscription	Demand pull: Subsidy(Ⅱ-2)
2003	***Government IT Policy Strategy Group***[5] The government aimed to promote ICT infrastructure and broadband with policies focused on the use of ICT. The government itself is required to set a good example of ICT use.	Reducing private operators' costs of deployment Increasing value of broadband access	Supply push and demand pull: Innovation directive(Ⅰ-4) Knowledge deployment(Ⅱ-1)

Year	Policies examined	Objective	Institutional actions
2005	***New national ICT strategy*** ***From an IT policy for society to a policy for the information society*** The new strategy mainly deals with activities to support disabled people taking part in the information society and action plans for increased equalities in the IT business, and requires that government agencies with their own IT infrastructure should contribute to IT development in the administration.	Increasing broadband penetration by direct investment to broadband infrastructures	Supply push and demand pull: Subsidy(Ⅰ-3) Innovation directive(Ⅰ-4) Knowledge deployment(Ⅱ-1)
2006	***Territorial mapping programs*** In order to provide detailed information on existing broadband coverage and eventually on the potential demand expressed in different geographic locations of the country, the Swedish Information Technology Policy Group has introduced a public register of excavations made by local administrations, aiming at supporting investment decisions by private operators (Belloc et al., 2011, p. 9).	Enhancing private operators' access to the market	Supply push: Knowledge deployment(Ⅰ-2)
2008	***Government funding*** Between 2009 and 2013, grants of $500 million were provided to encourage the development of broadband infrastructure in areas with no providers, and subsidies were aggressively used to spur broadband deployment, particularly in rural areas of the country[6]. Tax reductions were allowed for broadband access installations in high-cost areas and funding to local authorities that establish operator-neutral networks in rural and remote areas. Established a $26 million project to raise IT literacy among schoolteachers[7].	Increasing broadband penetration by direct investment in broadband infrastructure Increase value of broadband access	Supply push and demand pull: Subsidy(Ⅰ-3) Innovation directive(Ⅰ-4) Knowledge deployment(Ⅱ-1)
2009	***Broadband Strategy for Sweden[8]*** Broadband Strategy for Sweden was released, setting a goal that 90% of households should have access to a broadband connection of at least 100 Mbit/s by 2020.	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy(Ⅰ-3) Innovation directive(Ⅰ-4)

Note 1: Hall. M., Ministry of Industry, Employment and Communications (see http://www.oecd.org/sti/broadband/33864880.pdf).
Note 2: *Swedish commitment to broadband both in the cities and in the countryside*, p.13 (see http://www.oecd.org/sti/ieconomy/2736714.pdf).
Note 3: Swedish commitment to broadband both in the cities and in the countryside, p.10 (see http://www.oecd.org/sti/ieconomy/2736714.pdf).
Note 4: *Explaining International Broadband Leadership*, p. G2 (see http://www.itif.org/files/ExplainingBBLeadership.pdf).
Note 5: *Explaining International Broadband Leadership*, p. 20 (see http://www.itif.org/files/ExplainingBBLeadership.pdf).
Note 6: *Explaining International Broadband Leadership*, p. G1 (see http://www.itif.org/files/ExplainingBBLeadership.pdf).
Note 7: *Explaining International Broadband Leadership*, p. G4 (see http://www.itif.org/files/ExplainingBBLeadership.pdf).
Note 8: *Broadband Strategy for Sweden* (see http://www.government.se/content/1/c6/13/49/80/112394be.pdf).

The Swedish government has been actively involved in rolling out broadband infrastructure through public investment. Supply-side policies to promote broadband penetration have been widely employed by the Swedish government since 2000, and the penetration growth rate has increased from then on, as depicted in Figure 4.3. Until 2007, growth slowed as the market matured, and supply-side policies were adopted mainly to support infrastructure development in remote areas. However, it must be mentioned that early in 1998, the Swedish government implemented demand-side policies to increase PC ownership and raise the public perception of broadband as a better Internet access technology, considering that previous empirical research (Trkman et al., 2008; Kyriakidou et al., 2012) has shown that higher computer penetration significantly enables broadband penetration.

4.2.3. South Korea

South Korea has a high population density (509 inhab/km^2) (World Bank, 2012), with 83.2% of the population living in urban areas (World Bank, 2012). Broadband services were first launched in Korea in 1998. Its broadband penetration rate was the highest in the world from 2000 to 2006. Additionally, the speed with which Korea's broadband market developed is remarkable.

South Korea's success as a world leader in broadband was due to the regulatory regime, aggressive government programs, and projects focused on boosting broadband demand.

After the privatization of the state-run telecommunications provider, Korea Telecom (KT), and the encouragement of new entrants into the broadband market in the late 1990s, digital subscriber line (DSL) and cable broadband services expanded rapidly (see Figure 4.2). The broadband sector's regulatory environment evolved in three phases. In the introduction stage, light regulation was a means of promoting competition. Broadband was classified as a value-added service, and all types of broadband-access technology were permitted. Facilities-based competition[17] started to take off because of the low entry barriers. The second stage was from 2005 to 2007, when regulation increased as a response to the growing dominance of KT. Price regulations were introduced in 2005, and broadband was reclassified as a facilities-based service. In the third stage, there has been a move back toward lighter regulation in some areas because the market has matured.

Aside from regulatory actions, direct public policies have been widely advocated by the South Korean government.

[17] Facilities-based competition is the competition among platforms with different or same technologies, such as digital subscriber line and cable modem.

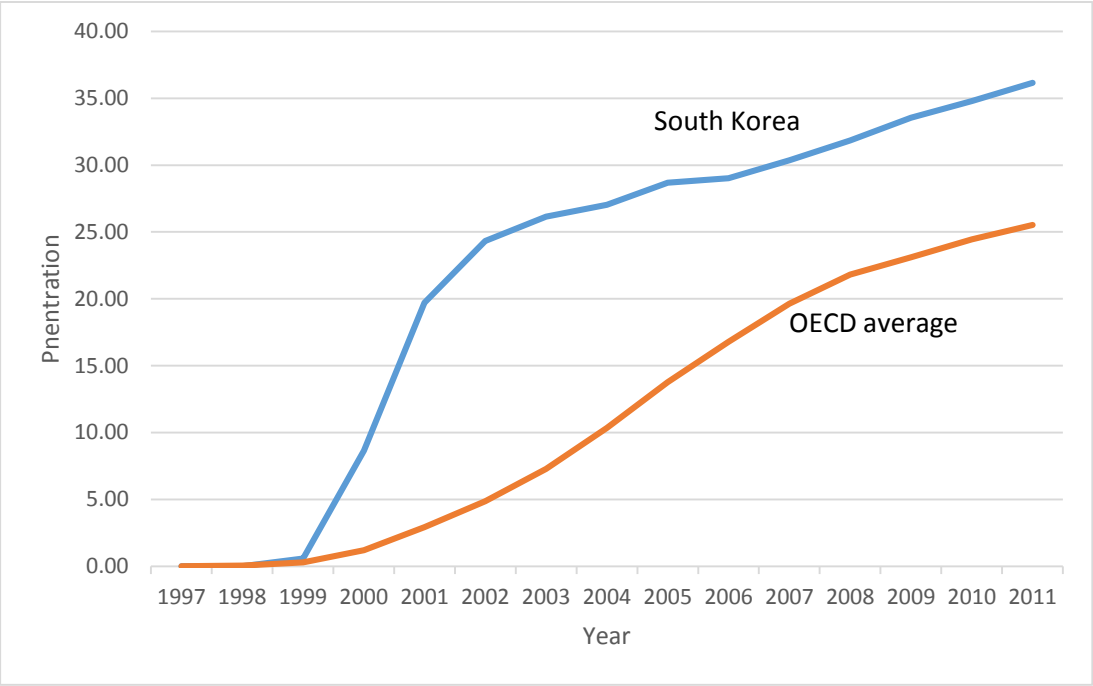

Figure 4.2 Broadband growth from 1997 to 2011 in South Korea

Source: Created on the basis of OECD (2014).

Table 4.3 Public Policies in South Korea

Year	Policies examined	Objective	Institutional actions
1987	***e-Government initiative and National Knowledge Information Resource Management Project***[1] Since 1987, the government has been involved in building e-government infrastructure, digitizing information and developing e-government systems and services, and implementing the National Knowledge Information Resource Management Project.	Increasing value of broadband access	Demand pull: Knowledge deployment (Ⅱ-1)
1993	***KII-initiative*** [2] KII-initiative includes three aspects: KII-G, KII-P, and KII-T. KII-G: Constructing a national high-speed public backbone network via long-term loan programs for broadband suppliers and national financing programs. KII-P: Using funding to construct an access network for homes and businesses. KII-T: Focusing on R&D support.	Increasing broadband penetration by direct investment in broadband infrastructure Reducing private operators' costs of deployment Enhancing private operators' costs of deployment	Supply push: Knowledge building (I-1) Knowledge deployment(I-2) Subsidy (I-3) Innovation directive (I-4)
1997	***Cyber Building Certificate System***[3] Cyber Building Certificate System (territorial mapping programs) was built in order to transmit information to telecom operators and provide incentives to real estate developers to coordinate with telcos to include fiber optic connections in new buildings.	Enhancing private operator's access to the market	Supply push: Knowledge deployment (I-2)
1999–2002	***Cyber Korea 21***[3] The project aims to support R&D and technology development activities in IT via government investment and long-term loans. Supports emerging Internet-related sectors, including software, digital contents, and IT parts and components by tax reductions. Facilitates e-commerce and promotes information sharing between firms in a safe and reliable online business environment. Subsidized training courses are provided and free personal computers given to schools.	Reducing private operators' costs of deployment Increasing broadband penetration by direct investment in broadband infrastructure Increasing value of broadband access	Supply push and demand pull: Subsidy (I-3) Innovation directive (I-4) Knowledge deployment (Ⅱ-1)
2000	***Ten Million People IT Education Project*** The project provides incentives for private demand (e.g., free or subsidized training programs to individuals and institutions) (Lee, et al., 2003).	Increasing value of broadband access Reducing cost of broadband subscription	Demand pull: Knowledge deployment (Ⅱ-1) Subsidy (Ⅱ-2) Mobilization (Ⅱ-3)

Year	Policies examined	Objective	Institutional actions
2002–2004	***e-Korea Vision 2006 and Broadband IT Korea Vision 2007***[1] The initiatives were launched to support IT venture start-ups and facilitate penetration of overseas IT markets, further develop the quality of e-government services, increase public/business participation in e-government, and expand ICT use in school and e-learning opportunities.	Enhancing private operators' access to the market Increasing value of broadband access	Supply push and demand pull: Knowledge deployment (I-2) (Ⅱ-1)
2004	***Broadband Convergence Network, IT839*** [2] Low-cost loans were provided to broadband providers to build high-speed networks, while government investment in BcN were directed largely into R&D activities.	Reducing private operators' cost of deployment	Supply push: Knowledge building (I-1) Subsidy (I-3)
2006–2007	***Ubiquitous-IT839***[1] The project helps companies to commercialize leading technologies and provides financial support and tax benefits for R&D. Besides, it also takes the lead in global standardization, supports cooperation and convergence among companies as well as the establishment of u-payment and u-banking systems, and further develops and customizes e-learning services and content.	Reducing private operators' cost of deployment Increasing value of broadband access	Supply push and demand pull: Knowledge building (I-1) Subsidy (I-3) Innovation directive (I-4) Knowledge deployment (Ⅱ-1)
2007	***Cyber-Infrastructure Grid***[1] The project provides support for building a high-performance research infrastructure that can dynamically collect, integrate, and share distributed and disparate resources, such as supercomputers, large-scale storage, and advanced instruments.	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy (I-3) Innovation directive (I-4)
2009	***Ultra Broadband Convergence Network***[1] The project was announced to further upgrade the BcN access network to enable a 1Gbps service speed on the fixed network. Public money will be spent on supporting technology development, building a test-bed environment and verifying new service models.	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy (I-3) Innovation directive (I-4)

Note 1: *Broadband Policy Development in the Republic of Korea* (see http://www.infodev.org/infodev-files/resource/InfodevDocuments_934.pdf).
Note 2: Republic of Korea, Ministry of Information and Communication (see http://www.krnet.or.kr/board/data/dprogram/598/G2-1%B1%E8%C4%A1%B5%BF.pdf).
Note 3: Republic of Korea, National Information Society Agency (see https://www.itu.int/ITU-D/asp/CMS/Events/2010/Thailand-Broadband/Session1a_Young_Min_Ko.pdf).

The Korean government has taken great interest and has played a significant role in the country's broadband development by launching a series of related technological initiatives. Korea was the first to establish a national policy to promote the deployment of information technology in the public and private sectors with its "Framework Act on Informatization Promotion" as early as 1987. Compared to other countries, the Korean government began to promote the use of IT in government agencies and digital literacy at a very early stage. From the mid-1990s on, the government has announced ambitious supply-side policies, such as KII, BcN, and UBcN, to construct an advanced information and communication infrastructure at the national level. Along with the supply-side policies, the Korean government has also implemented a number of demand-side initiatives to promote broadband penetration. However, in recent years, government interventions have primarily focused on the supply side to support technology development.

4.2.4. Australia

Australia has an extremely low population density—less than 3 inhab/km^2 (as compared to 22 in Sweden and 508 in South Korea) (World Bank, 2012). However, the majority of its citizens are clustered in the major metropolitan centers, with the urban population being 89%. Broadband in Australia started slowly. Telstra launched the first DSL services in 2000. Australia was well behind the OECD average for total broadband subscribers per 100 inhabitants until 2005.

Many regulatory initiatives were introduced; for example, local loop unbundling was first introduced in 1999 (Eady, 2007, p. 9). However, since price controls were imposed by regulation, there were several years of continuous conflicts over the pricing of local loop unbundling. Australia was described as having no effective regulated rate by late 2006 (OECD, 2009, p. 50). By 2008, the dispute was resolved, and the subsequent local loop unbundling prices were in line with prices elsewhere in the world (OECD, 2009, p. 50). The ambitious program of the state-owned National Broadband Network (NBN) may face fierce competition from Telstra.

The Australian government also shows great interest in direct public policy. Table 4.4 details the history of Australia's broadband initiatives.

Australia's direct public policies have largely been implemented as supply-side initiatives, while demand-side policies were not perceived as important for national broadband success. By 2006, demand-side subsidies were introduced to increase broadband penetration. The government continues to show great propensity for building infrastructure, as seen in the large public investment allocated to the ambitious NBN program.

Table 4.4 Public Policies in Australia

Year	Policies examined	Objective	Institutional actions
1996	***National digital divide policy*** The first national digital divide policy, *Network the Nation* (NTN), was announced by the government in 1996. NTN aimed to enhance telecommunications infrastructure and services, increase access to, and promote use of, services available through telecommunications network, and reduce disparities in access to such services and facilities (Notley and Foth, 2008, p. 4). A total of $351 million was allocated to 762 projects across regional, rural, and remote Australia during 1997–2004, using funds allocated from the sale of the national telecommunications carrier, Telstra[1].	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy (I-3) Innovation directive (I-4)
2002	***Government fund*** The 2002 *Telecommunications Action Plan for Remote Indigenous Communities* pledged $8.3 million over three years to promote broadband rollout in indigenous communities[2].	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy (I-3) Innovation directive (I-4)
2003	***National Broadband Strategy*** The national broadband strategy was announced[3]. The Higher Bandwidth Incentive Scheme (HiBIS) was created to provide subsidies to service providers to offer broadband services in regional areas at prices reasonably comparable with those in urban areas. A demand aggregation initiative was launched, and funding was provided to coordinate broadband demand in local areas to attract additional infrastructure investment.	Reducing private operators' costs of deployment	Supply-push: Subsidy(I-3) Innovation directive(I-4)
2004	***Government fund*** The Coordinated Communications Infrastructure Fund (CCIF), which committed $23.7 million, was established to accelerate the rollout of broadband into remote areas[4].	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy (I-3) Innovation directive (I-4)
2005	***Communications Fund* and *Connect Australia*** A Communications Fund was established with a corpus of $2 billion to finance telecommunications services in rural, regional, and remote areas[5]. The Connect Australia project committed $1.1 billion over three years to rollout broadband among people living in regional, rural, and remote areas, build new regional communications networks, and set up telecommunications services for remote indigenous communities[6].	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy (I-3) Innovation directive (I-4)
2006	***Subsidy*** A series of programs were established and per-customer subsidies were provided to ISPs	Reducing private operators' costs of deployment	Demand-pull: Subsidy (Ⅱ-2)

Year	Policies examined	Objective	Institutional actions
	offering services in remote areas. Subsidizing Telstra to upgrade its fixed line network to FTTN. The 2006 Backing Indigenous ability committed $36.6 million to redress low levels of telecommunications access in Indigenous communities[3].		
2008	***Digital Education Revolution*** The federal government spent AUD 2.2 billion on this program (Digital Education Revolution) to increase computer availability in schools to one per student in years 9–12 by the end of 2011. The program also supports IT training for teachers, provides online curriculum tools and resources, and funds connections for schools[7]. Backing Indigenous Ability (BIA) aimed to increase awareness, digital literacy, and ICT skills[8].	Increasing value of broadband access	Demand pull: Knowledge deployment (Ⅱ-1) Mobilization (Ⅱ-3)
2009	***Public-private partnership*** The Australian government announced a national strategy, the National Broadband Network (NBN), which aims to build a 100 Mbps FTTH network for 90% of its citizens. A company (NBN Co) was established to build and operate the NBN[9]. This nationally funded fiber network will be privatized after completion to a fully open access carrier.	Increasing broadband penetration by direct investment in broadband infrastructure	Supply push: Subsidy (I-3) Innovation directive (I-4)

Note 1: Australia, Dept. of Communications Information Technology and the Arts (see http://www.anao.gov.au/Publications/Audit-Reports/1998-1999/Networking-the-Nation-The-Regional-Telecommunications-Infrastructure-Fund).
Note 2: Australia, Australian Communications and Media Authority, *Telecommunications in Remote Indigenous Communities*, p.9 (see http://www.acma.gov.au/webwr/_assets/main/lib310210/telecommunications_in_rics_2008.pdf).
Note 3: Australia, Dept. of Communications, Information Technology and the Arts. *Evaluation of appropriateness, effectiveness and efficiency of the program,* p.18 (see http://www.archive.dcita.gov.au/2005/08/national_communications_fund).
Note 4: Australia, National Office for Information Economy (see http://www.moore.org.au/senh/01/CoordCommsInfrastructureFund.pdf).
Note 5: Australia, Dept. of Communications, Information Technology and the Arts, *Evaluation of appropriateness, effectiveness and efficiency of the program*, p.16 (see http://www.archive.dcita.gov.au/2005/08/national_communications_fund).
Note 6: Australia, Dept. of Communications, Information Technology and the Arts. *Evaluation of appropriateness, effectiveness and efficiency of the program*, p.20 (see http://www.archive.dcita.gov.au/2005/08/national_communications_fund).
Note 7: Australia, Dept. of Education and Training, Digital Education Revolution Program Review (see https://docs.education.gov.au/documents/digital-education-revolution-program-review).
Note 8: Australia, Dept. of Communications, Information Technology and the Arts, *Backing Indigenous ability: delivering a comprehensive telecommunications package in indigenous communities* (see http://trove.nla.gov.au/work/20624440?q&versionId=24447419).
Note 9: Australia, Dept. of Communications (see http://www.communications.gov.au/broadband/national_broadband_network).

4.3. Comparative analysis

As we have discussed in chapter two that socioeconomic factors are able to influence broadband penetration rate, we need to look into the status of urbanization, population density, GDP per capita, and broadband price in selected countries (Figure 4.3)

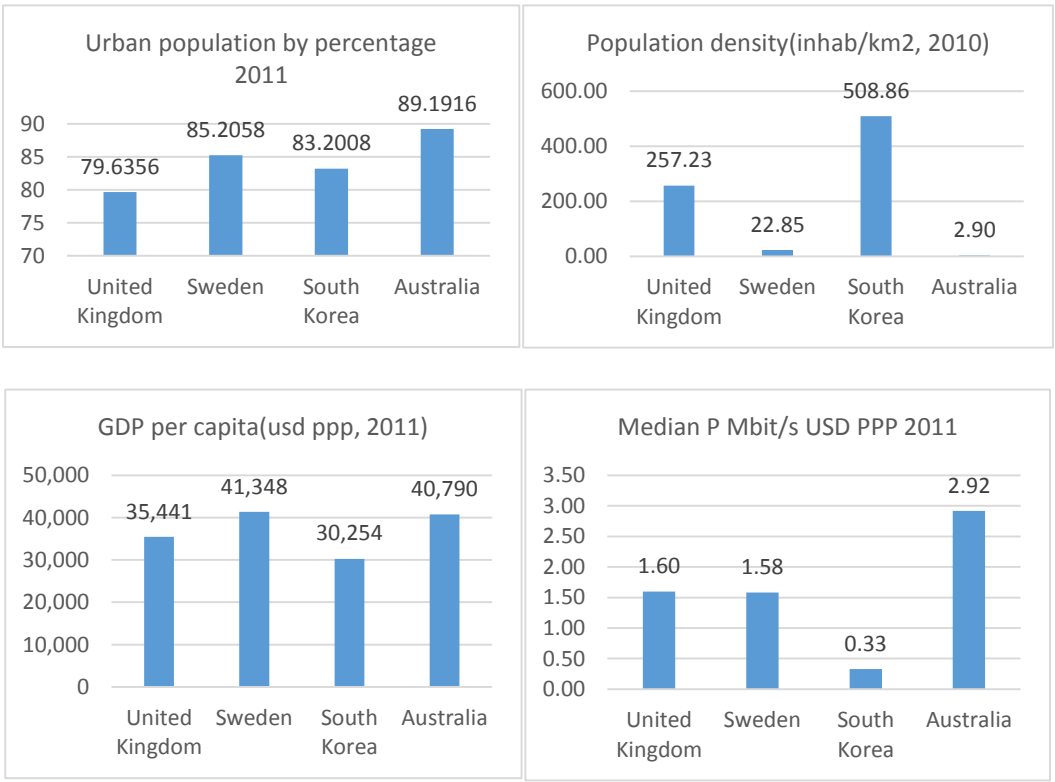

Figure 4.3 Urbanization, population density, GDP per capita, and broadband price in selected countries

Source: Created on the basis of OECD (2014).

Figure 4.3 provides a comparison of urbanization, population density, GDP per capita, and broadband price in selected countries. These socioeconomic factors are considered to have influence on broadband penetration, which is presented in chapter two (Table 2.1). We can see from the figure that the four countries are differ from each other in the aspects of

socioeconomic factors. Particularly, population density in Australia and Sweden are much lower than South Korea and UK. South Korea has the highest population density (508.86) among the four countries, while there are less than 3 inhab/km2 in Australia. People in South Korea also enjoy the cheapest broadband access with 0.33 per Mbit/s USD PPP.

Apart from the above differentiation, we also find the four countries have implemented different type of policies. Through this in-depth comparative analysis that incorporates a time dimension into the framework, the transition of direct policy toward broadband in selected countries can be described as seen in Figure 4.4. Figure 4.5 shows the growth of broadband penetration in these four countries.

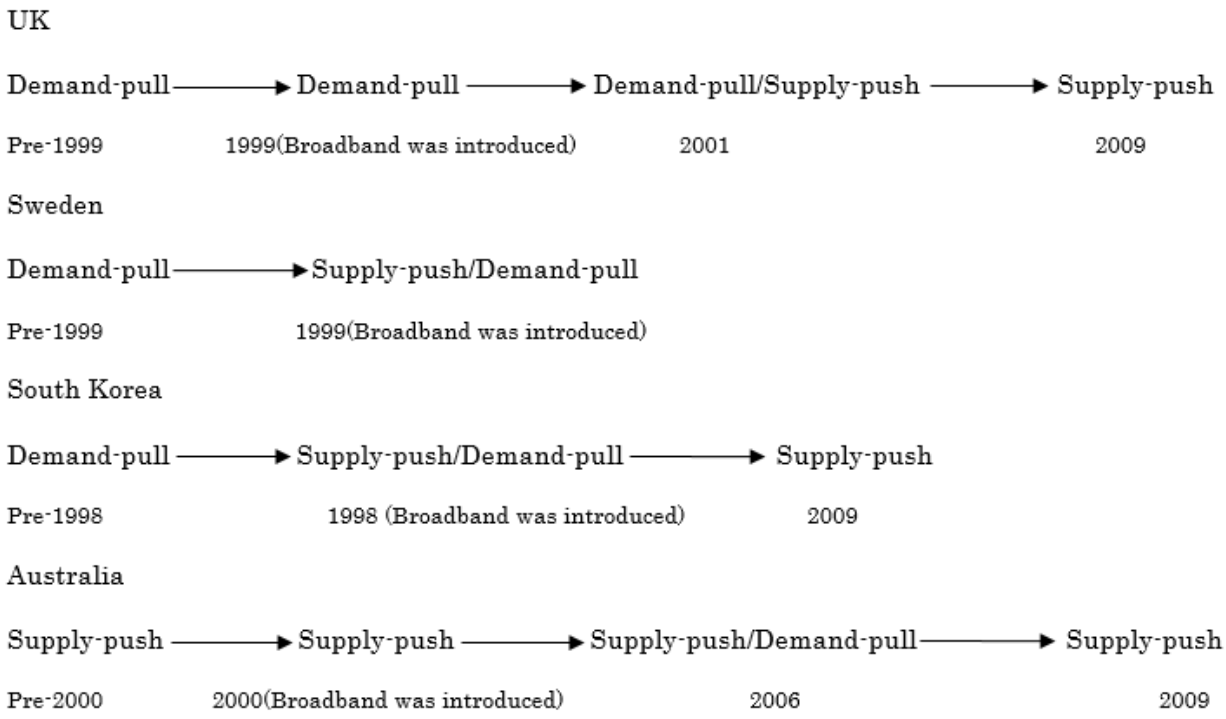

Figure 4.4 The transition of policies

Source: The author

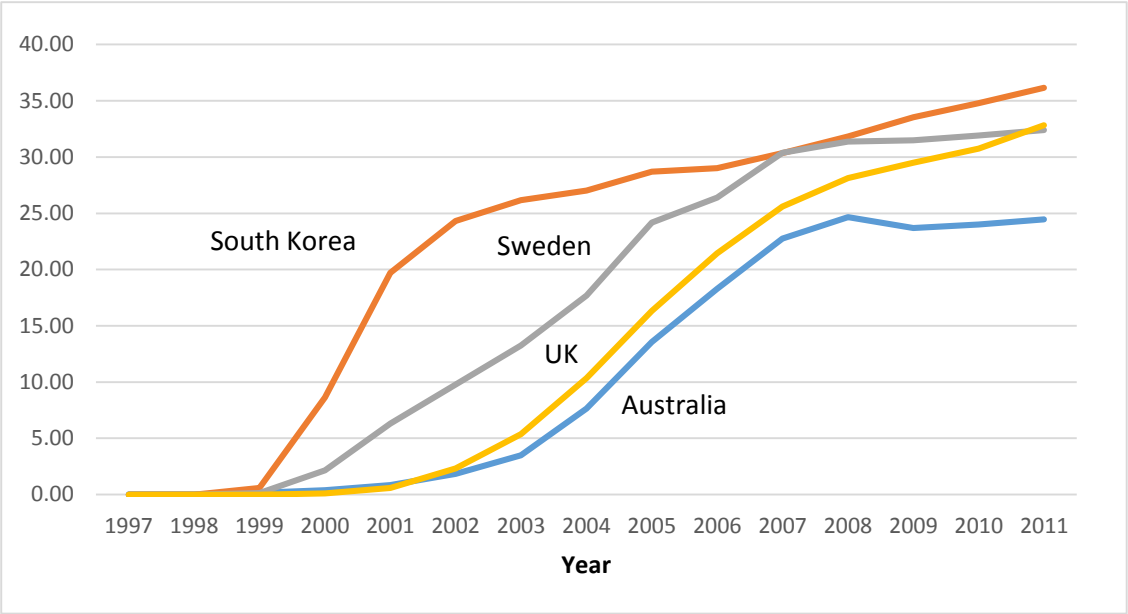

Figure 4.5 Broadband growth in selected countries from 1997 to 2011

Source: Created on the basis of OECD (2014).

South Korea and Sweden, as top performers in broadband, have been actively involved in rolling out broadband infrastructure through public investment. The Korean government established a national policy, "Framework Act on Informatization Promotion," to promote the deployment of information technology in both public and private sectors as early as 1987. This Act created programs that promote both public access to broadband and digital literacy. Later, many more initiatives and programs were established, with a substantial amount of money from the government budget to stimulate private investment. Similarly, the Swedish government recommended that the state should take action in rural areas where there was no market deployment and committed over EUR 600 million for the installation of a national backbone as early as 1999. The government has subsidized broadband

infrastructure development through a variety of programs and projects, including funding to local authorities that establish operator neutral networks in rural areas, provide tax reductions for broadband access installations in high cost areas, and require state-owned companies to build a high-speed backbone infrastructure for emergency services. The Swedish government has allocated a substantial amount of money to stimulate this infrastructure development.

In addition to these supply-side interventions to support broadband infrastructure development, the two governments also created programs to encourage broadband demand. The Korean government enacted a number of successful efforts to spur broadband demand and digital literacy. For instance, the government provided free computers to low-income students with good grades and established programs that require teachers to encourage students' Internet usage via online assignments and email communication. Its digital literacy programs targeted groups less likely to use the Internet. Likewise, in addition to the large number of public investments in infrastructure, the Swedish government also supported initiatives to promote demand for broadband usage by fostering digital literacy, encouraging the use of broadband for education, and increasing access to personal computers. It launched a $25 million project to raise IT literacy among schoolteachers in order to increase demand for broadband. Apart from jointly adopted demand-side interventions promoting broadband penetration, both the Korean and Swedish governments established PC

penetration promotion (PC purchase installment plan in Korea in 1999 and tax breaks for companies that supplied employees with PC in Sweden in 1998) before broadband was introduced to the market, since broadband demand would not increase if citizens did not have access to a PC at home.

Compared to Korea and the UK, the Australian government has attempted to achieve broadband penetration by focusing merely on supply-side initiatives, with little effort to expand demand. Even the government change[18] in 2007, public intervention had shifted back toward higher public investment in telecoms infrastructure. That national government established a Communications Fund to generate an annual revenue stream to fund new technologies in rural areas and agreed to provide subsidies for Telestra to upgrade its fixed line network to Fiber To The Node (FTTN). In 2009, the national government announced a broadband strategy called the National Broadband Network (NBN). A new company will be established to build and operate the NBN, at a cost of USD 36.5 billion. The plan aims to replace Australia's copper exchange lines with Fiber To The Premises (FTTP) and deliver a download speed of 100 Mbps to 90% of homes and workplaces. The other 10% of the population will get speeds of at least 12 Mbps by other means within eight years. However, despite the highly supported deployment of broadband infrastructure, the rate of the broadband penetration had long remained under the OECD average (Figure 4.6).

[18] With the 2007 federal elections, the Australian government changed from the Liberal Party to the Labor Party.

Furthermore, demand-side public intervention is limited. There were few demand programs until the "Digital Education Revolution" established by the federal government in 2008. Most of the funds were spent to increase the number of computers in schools.

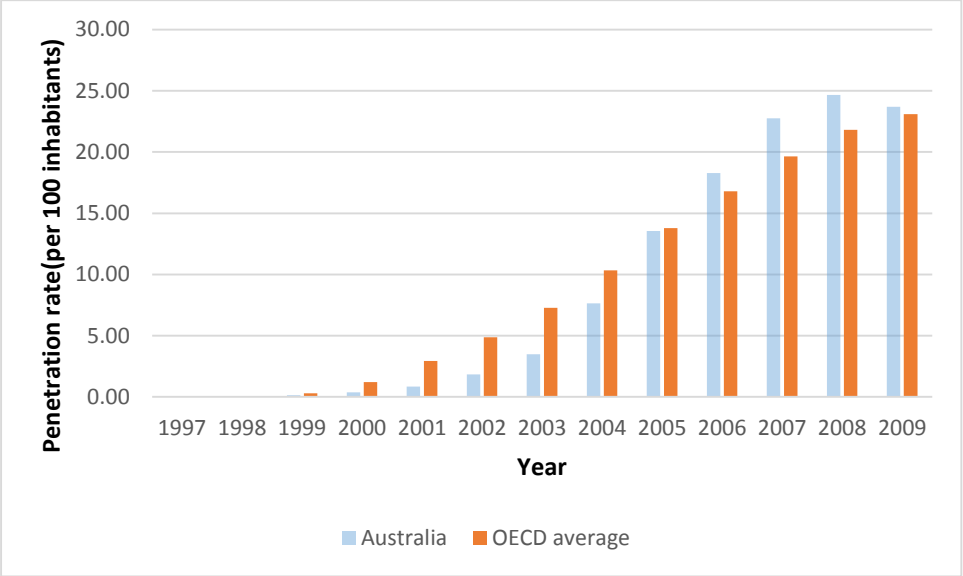

Figure 4.6 Fixed broadband penetration in Australia versus OECD average

Source: Created on the basis of OECD (2014).

In contrast, the UK， an early leader in reforming telecommunications markets, has relied largely on market forces to deploy broadband services. It established a national broadband strategy in 2001 through its White Paper "Opportunity for All in a World of Change." Its objective was to have the most extensive and competitive broadband market in the G7 by 2005. Funding was made available through the Broadband Aggregation Project, which aggregated demand for broadband connectivity to make broadband infrastructure deployment more attractive for operators. In 2005, the UK government's digital strategy was released, also focusing on the demand side of broadband by fostering the creation of

innovative broadband content, promoting virtual learning, providing communal access points, providing digital literacy programs for adults, removing access barriers for people with disabilities, and making home computers more affordable[19]. Since the UK has many rural areas, supply-side intervention has been mainly focused on supporting broadband infrastructure development in rural areas.

Notwithstanding the distinctive difference in policy approaches among the four countries, a more thorough look at them reveals that they have much in common. First, countries with a large amount of support to stimulate broadband infrastructure deployment have succeeded in increasing the coverage rate of broadband. Although this does not necessarily result in a high penetration rate, as depicted in Figure 4.7, it is assumed that services taking advantage of broadband will follow once it is supplied. Second, countries that are often cited as global leaders in broadband penetration have developed extensive programs to generate demand for broadband services.

[19] The Prime Minister's Strategy Unit and Department of Trade and Industry, "Connecting the UK: The Digital Strategy" (March 2005): 8.

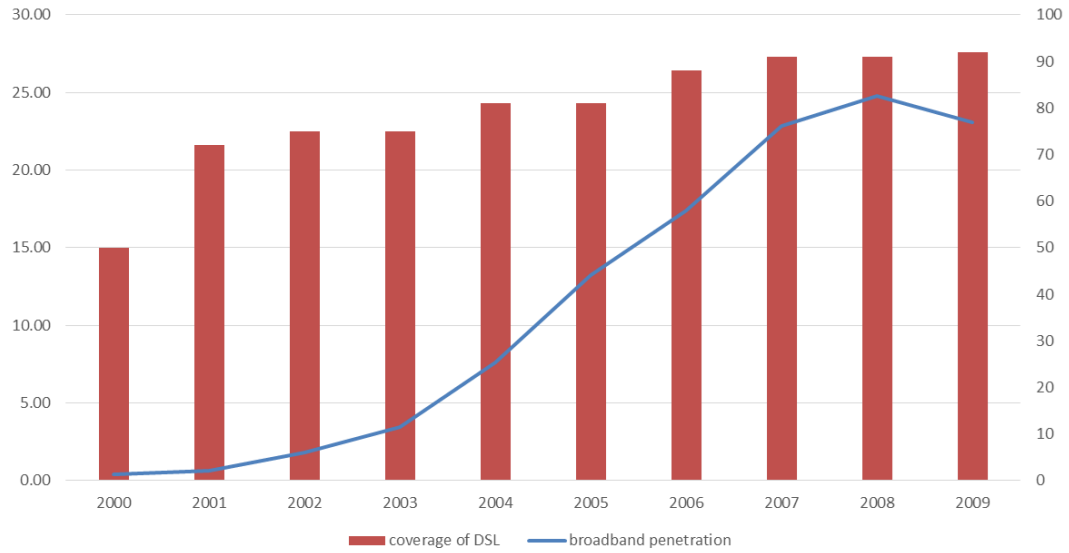

Figure 4.7 Fixed broadband penetration and DSL coverage (population covered) in Australia

Source: Created on the basis of OECD (2014).

4.4. Summary

This chapter provides an in-depth analysis of public policies at the national level in four countries: the UK, Sweden, South Korea, and Australia. These four countries have adopted various broadband strategies to boost broadband penetration. The UK, Sweden, and South Korea have been actively involved in promoting broadband penetration through both demand- and supply-side policies, and are shown to be top performers in broadband among OECD countries. However, the Australian government has attempted to achieve broadband penetration by focusing merely on supply-side policies, with little effort to expand demand. It is noteworthy that Australia is well behind the OECD average broadband penetration rate.

Chapter 5 Empirical analysis on 30 OECD countries

5.1. Overview

In chapter four, it is found that different policymakers have adopted various combinations of instruments in their direct interventions, leading to differing outcomes in broadband penetration. Consequently, questions may arise: Is broadband penetration driven by market demand or supply push? Should demand- and supply-side public policies have the same impact on broadband penetration? In this chapter, we propose a hypothesis based on our case study findings: Demand-side policies are more productive than supply-side policies in stimulating broadband penetration.

Specifically, we need to test the following hypotheses:

H1: Demand-side policies have a positive impact on the broadband penetration rate.

H2: Demand-side policies have a greater impact on the broadband penetration rate than supply-side policies.

H3: Jointly adopted policies should be the most productive way of promoting broadband penetration.

Regression analysis results based on data from 30 OECD countries show that H1 and H2 are accepted but H3 is rejected. The chapter is structured as follows. The hypothesis is proposed in section 5.2. Section 5.3 illustrates the methodology and data used to test the hypothesis. Section 5.4 provides the estimation results. We end with a summary and

discussion in section 5.5.

5.2. Hypothesis proposition and implications

Innovation researchers have long debated whether innovations are driven by market demand or technological shifts. The market demand school of thought holds that organizations innovate based on market needs; however, technology proponents claim that technological change is the major driver of innovation. Chidamber and Kon (1994) provide a survey of the literature regarding the technology-push (i.e., supply-push) versus demand-pull debate on technological innovation. The authors conclude that, despite inconclusive or even opposite results obtained by innovation researchers, there is one key observation in all the studies: "in the short term, incremental innovations which constitute the bulk of successful innovations, are launched into existing markets, or markets whose near term needs are well known; market demand is a clear requisite for success" (Chidamber and Kon, 1994, p. 107).

However, whether broadband, as an innovation product, is subject to demand pull or supply push has not been fully discussed. From the observations of this study, we may propose that countries with a commitment to demand-side interventions, or jointly implemented demand- and supply-side policies, have reached a higher broadband penetration rate relatively faster, while countries that relied solely on supply-side policies have lagged behind their counterparts (as Figure 4.4 shows in chapter four). Thus, the

following hypothesis is proposed:

Broadband diffusion is more likely to be demand-constrained rather than supply-constrained; thus, public interventions are much more effective on the demand side than on the supply side (Cheng, 2014a).

This hypothesis has three implications:

1. *Broadband is primarily demand-constrained, and market users are the key driving forces.*

   In light of the fact that government interventions have historically focused on supply-side efforts, the hypothesis may seem surprising. Furthermore, no empirical research demonstrates that market demand is the major factor in broadband penetration. However, justifications can be deduced from previous research and from the following two observations. (1) Theoretically, broadband is not only an innovation product but also an incremental product. Since other, less-advanced Internet access technologies (e.g., dial-up) were known by the consumer before, broadband, specifically, should be identified as an incremental innovation, since it is a manifestation of technical advance in communications technology. Thus, based on Chidamber and Kon's (1994) conclusion that market demand is requisite to the success of incremental innovations, it is reasonable to assume that user demand is the primary factor for the success of innovations and that markets should be the key

drivers of broadband penetration. (2) It can be observed that demand-side initiatives were implemented in both Korea and Sweden, both of which are regarded as top performers in broadband provision and penetration around the world. The demand-side approach was implemented before the supply-side initiatives, in order to raise the demand for broadband services. In contrast, there was little effort to generate demand in Australia. Both liberal (before 2007) and labor governments of Australia leaned toward supply-side policies with high public investment in telecommunications infrastructure. Consequently, broadband penetration is very low, even though broadband is highly accessible (Figure 4.7). Thus, it is hardly surprising that in the early 2000s Australia was well behind the OECD average for total broadband subscribers per 100 inhabitants.

2. *The impact of supply-side policies on broadband penetration might be overstated.*

It is a fact that governments worldwide have recognized the increasing importance of high bandwidth networks as drivers for economic and social development, and that the public sector is actively involved in the rollout to facilitate timely, sustainable, and nationally available broadband networks (Ruhle et al., 2011). Therefore, it is impossible to trace the performance of broadband penetration without any supply-side policies being adopted. However, as previously discussed, broadband is assumed to be an incremental innovative product. Demand for broadband existed before

broadband was introduced into the market. Thus, it might be reasonable to assume that services utilizing broadband will follow once broadband is supplied, leading to an increase in broadband penetration. That means supply-side policies, rather than being a necessity, play the role of facilitators in broadband penetration.

3. *Jointly adopted supply- and demand-side policies are the most effective in promoting broadband penetration.*

It is observed that countries that have implemented supply-side as well as demand-side policies have the greatest performance in broadband penetration. For example, in the case of Korea, which is considered a world leader in broadband, the government has long been involved in the promotion of broadband through both supply-side support, simulating investment in infrastructure deployment, and demand-side programs, generating demand for such services. Sweden, also considered one of the top performers in broadband provision and penetration, has not only been actively involved in rolling out broadband infrastructure through supply-side policies but has also supported initiatives to promote demand for broadband by fostering digital literacy, increasing access to PCs, and encouraging the use of broadband for education. Subsequently, Sweden emerged as one of the leaders in broadband penetration, speed, and affordability. Thus, it seems that jointly adopted policies are the most effective in promoting broadband penetration.

As such, in order to empirically test the hypothesis, we may interpret it as follows: demand-side policies are more productive than supply-side policies in stimulating broadband penetration.

Specifically, we have the following three hypotheses (these will be tested through econometric methods in the next chapter):

H1: Demand-side policies have a positive impact on the broadband penetration rate.

H2: Demand-side policies have a greater impact on the broadband penetration rate than supply-side policies.

H3: Jointly adopted policies should be the most productive way of promoting broadband penetration.

5.3. Regression analysis

This section intends to test the hypothesis with regression analysis based on data from 30 OECD countries where the broadband market is fully competitive[20] (ITU, 2012). In order to verify the hypothesis proposed in the previous section, the estimation model is generated as follows:

[20] Competition level is the average of 19 telecommunications services (e.g., local services, fixed long distance, wireless local loop, data, DSL, cable modem, VSAT, and leased lines).

$$\ln(penetration_{it}) = \beta_0 + \beta_1 \ln(Urbanization_{it}) + \beta_2 \ln(GDPpc_{it}) + \beta_3 \ln(Density_{it}) + \beta_4 \ln(Price_{it}) + \beta_5 Reg_{it} + \delta_{\mathrm{ds}} D1_{it} + \delta_{\mathrm{s}} D2_{it} + \delta_{\mathrm{d}} D3_{it} + a_i + u_{it} \quad (1)$$

where $\mathrm{penetration}_{it}$ refers to the number of fixed broadband subscribers per 100 people of country *i* in year *t*. $\mathrm{Urbanization}_{it}$ is the population in cities, calculated by percentage of urban population. GDP_{it} is measured in current US dollars. $Density_{it}$ represents population density by people per square km of land area. $Price_{it}$ denotes broadband prices per megabits per second in country *i* at year *t* (USD PPP). Reg_{it} is a dummy variable that takes the value one if unbundled access to the local loop is required in country *i* at year *t*, and 0 otherwise. These control variables are selected based on the results of previous empirical studies, presented in chapter two (see Figure 2.1).

In this equation, $D1_{it}$ is a dummy variable that takes the value of one if country *i* has initiated both demand- and supply-side policies in year *t*; otherwise, $D1_{it} = 0$. $D2_{it}$ is a dummy as well. It takes a value of one where country *i* has implemented supply-side policies with the aim of stimulating broadband penetration by supporting operators; its value is zero otherwise. Similarly， $D3_{it}$ = 1 denotes that demand-side policies were employed in country *i* in year *t*; it is 0 otherwise. It is assumed that the country's demand- or supply-side policies once implemented has a durative effect; that is, the dummy variables of the country are compiled into one since the year the policy was initiated. Therefore, the

positive coefficients of $D3_{it}$, $D2_{it}$, and $D1_{it}$ indicate that broadband penetration was promoted by demand-side policies, supply-side policies, and combination strategies, respectively. The exact definition of *D1*, *D2*, and *D3* are presented in Table 5.1. The number of countries (among the 30 OECD countries studied) that adopted supply- or demand-side policies to promote broadband can be found in Appendix. From the table, we see that 7 of the 30 countries had adopted supply-side policies by 2001, and 28 by 2011. Moreover, 7 countries had implemented demand-side policies, too, by 2001, and 29 by 2011.

Table 5.1 Definition of variables

	Variables	Definition	Expected signs of estimation	Source
Dependent variable	Penetration	Fixed broadband subscribers per 100 inhabitants (adoption)		OECD (2012)
Independent variables	Urbanization	Urban population as percentage of total population	+	World Bank (2012)
	GDPpc	GDP per capita, USD PPP	+	World Bank (2012)
	Density	People per square km	+	World Bank (2012)
	Price	Broadband prices per megabits per second, USD PPP	-	OECD (2014)
	Reg.	Dummy variable; 1 is assigned if unbundled access to the local loop is required in that year, and 0 otherwise	+	ITU (2012)
	D1	Dummy; coded as 1 for the years in which both supply- and demand-side policies were implemented	+	Author
	D2	Dummy; coded as 1 for the years in which supply-side policies were implemented; otherwise, D2 = 0	+	Author
	D3	Dummy; coded as 1 for the years in which demand-side policies were implemented; otherwise, D3 = 0	+	Author

Source: Author

In the estimation, the yearly panel data for the 30 OECD countries are from 2006 through 2008. The independent variable is the number of fixed line broadband subscriptions

per 100 inhabitants, as reported by ITU (2012). When broadband was first introduced in the market, countries with low broadband penetration yielded a long tail of small values in the distribution of the number of subscriptions per 100 people[21]. Therefore, the natural logarithm of this penetration variable is taken to be the dependent variable in the regression analysis. The independent dummy variables, for both demand- and supply-side policies, are compiled from information gathered on the different types of broadband promotion policies adopted, on both demand and supply sides, over the above period. In addition, because a country's profile influences its broadband penetration, other control variables, including urbanization, GDP per capita, and population density are considered. These data are obtained from the World Bank World Development Indicators (WDI) (World Bank, 2012) and OECD Broadband Portal (OECD, 2014). The 30 OECD countries are high-income economies with a high rate of fixed line broadband access. For instance, the OECD average penetration reached 24.67% by 2009, when only 3.5% of the population in the developing world were subscribers (OECD, 2014). Besides, the price divide among the sample countries is less. In 2008, the average fixed broadband price at purchasing power parity was $27.6 for developed countries and $289 for developing countries (United Nations, 2009, p. 20). All the countries except Mexico adopted unbundled regulation by 2009 (ITU, 2012). Variation among the 30 OECD countries based on urbanization and population density is

[21] Taking the logarithm helps to make the scales of all the variables comparable, such that when the matrix is inversed, the numerical problems would be fewer.

shown. However, variation within a country over time does not seem to be significant. Table 5.1 presents the definition of each variable, and Table 5.2 summarizes the descriptive statistics.

We then have the following expectations:

- If the coefficient for demand-side policy (δ_{d}) turns out to be statistically significant, the results would support hypothesis H1.
- If the coefficient for demand-side policy (δ_{d}) turns out to be significantly greater than the coefficient for supply-side policy (δ_{s}), the results would support hypothesis H2.
- If the coefficient for combination strategies (δ_{ds}) turns out to be statistically significant, there is a synergy between supply- and demand-side policies. If the coefficients for demand-side policy (δ_{d}) and supply-side policy (δ_{s}) turn out to be significantly less than $\delta_{\mathrm{ds}} + \delta_{\mathrm{s}} + \delta_{\mathrm{d}}$, the results would support hypothesis H3.

Table 5.2 Summary statistics

	Obs.	Mean	S.D.	Min	Max
Penetration (%)	326	16.51	11.33	0.01	39.96
Urbanization (%)	330	76.38	10.55	54.78	97.49
GDPpc (USD PPP)	330	31495.12	12537.22	8693.54	88796.88
Density (individuals/km^2)	330	139.36	131.90	2.53	512.66
Price (USD PPP)	150	3.58	8.45	0.06	81.13
Reg. (Dummy)	330	0.88	0.33	0	1
D1 (Dummy)	330	0.58	0.49	0	1
D2 (Dummy)	330	0.63	0.48	0	1
D3 (Dummy)	330	0.69	0.46	0	1

Source: Author

5.4. Estimation results

The study now intends to test the hypothesis with a regression analysis based on data from OECD countries with a fully competitive broadband market. The analysis uses panel data at the national level. In chapter three, we assumed that supply-side policies would decrease the price of broadband. Besides, the fact that demand-side policies could influence household income also needs to be considered. In order to deal with this issue, we employed lagged instrumental variables. Thus, the lagged values of ln(*Price*), ln(*GDPpc*), *D1*, *D2*, and *D3* are used as instrumental variables in the estimation. After estimating a fixed-effect and a random-effect instrumental variables model, we selected the latter according to the Hausman test[22].

[22] The Hausman specification test (H0: difference in coefficients not systematic, $chi^2 = 0.72$, Prob > $chi^2 = 0.9995$) suggested that the random-effects model is preferred.

The coefficients showing the effect of policy variables are presented in Table 5.3. The results report that only demand-side policy indexes (*D3*) have a positive and statistically significant effect on the broadband penetration rate at the country level, whereas the synergy and supply-side policy indexes (*D1* and *D2*, respectively) are not statistically significant. Among the variables that describe the profile of the country, GDP per capita and urbanization have a positive impact on broadband penetration in all of the models, but population density and regulation are not statistically significant. The cost of broadband subscription is found to exert a negative influence, significant at the 1% level, on broadband penetration.

Table 5.3 Results of estimation

Variable	Parameter	Coefficient	Std. Error
Dependent variable: ln(*Penetration*)			
ln*(Urbanization*)	β_1	0.9291***	0.2147
ln*(GDPpc*)	β_2	0.6205***	0.0782
ln*(Density*)	β_3	0.0060	0.0187
ln*(Price*)	β_4	-0.1399***	0.0294
Reg.	β_5	0.1564	0.1206
D1	δ_{ds}	-0.0476	0.3506
D2	δ_s	-0.1562	0.3361
D3	δ_d	0.2996*	0.1708
Constant	β_0	-7.6424***	1.1107

Source: Author

Notes: Number of observations is 90. Wald chi2(8) = 329.01, Prob > chi2 = 0.0000. Statistical significance is denoted as follows: *0.1 **0.05 ***0.01.

The results in table 5.3 show whether each hypothesis is verified.

H1: According to the estimation results for demand-side policies (*D3*), δ_d, the coefficient of D3, is positive, and significant at the 5% level. It shows that demand-side policies do have a positive impact on the broadband penetration rate. Thus, hypothesis H1 is accepted.

H2: The result of the F-test (H0: $D2 = D3$) is 0.0904. From this, δ_d and δ_s are statistically different at the 10% level. Therefore, demand-side policies have a greater impact on the broadband penetration rate than supply-side policies. This provides evidence to support hypothesis H2.

H3: The results show that δ_{ds} is not significant, implying that the combination strategy has no extra effect. Besides, the test (H0: $\delta_{ds} + \delta_s + \delta_d = 0$) is accepted[23]. Therefore, the combination strategy has no statistically significant influence, nor is it more effective than demand-side policies. Thus, there is no evidence to support hypothesis H3.

5.5. Summary and discussion

The results presented in the previous sections emphasize the critical role of demand-side policies in boosting broadband penetration. Our hypotheses concerning the significance of demand-side policies are confirmed by empirical analysis.

The regression analysis results, which reveal that only demand-side policies are

[23] H0: $\delta_{ds} + \delta_s + \delta_d = 0$. $chi^2(1) = 0.40$ Prob > $chi^2 = 0.5255$

significant and positive, directly verified hypothesis H1. As discussed in section 5.3, demand-side policies directly aim to strengthen consumers' awareness of the benefits of broadband and raise the willingness to pay for broadband services. Therefore, it is not surprising that these policies have a significant influence on broadband penetration. In addition, the results can also be interpreted to mean that Loss D, generated by involving consumers in the system, is covered by the positive impact resulting from relying on the market mechanism (Figure 3.2).

Hypothesis H2, supported by the results obtained from the F-test, probably deserves an in-depth discussion. Demand-side policies have a greater impact than supply-side policies, which in turn shows that the hypothesis in section 5.3 is valid. The positive impact resulting from the market mechanism is high enough to make public policies on the demand side work better than those on the supply side.

However, the results do not provide any evidence to verify hypothesis H3. Demand-side policies are found to have a greater impact on broadband penetration than the combination strategy, which implies that hypothesis H3 is rejected. It is proved that jointly adopted policies are not the most productive way to promote broadband penetration.

It may seem surprising that supply-side policies and the synergy between supply- and demand-side policies are not significant in the regression analysis. This may be explained in a rather straightforward manner. Supply-side policies aim to stimulate the rollout of

infrastructure by providing incentives to telecom operators, which results in increasing broadband availability. However, high availability of broadband connections does not necessarily imply a widely subscribed broadband service. There is no evidence that a service that takes advantage of broadband will follow once it is supplied? When we look at the experience of certain countries, Australia for instance, where broadband adoption had been very low despite the high availability of Asymmetric Digital Subscriber Line (ADSL) and cable modems, our skepticism seems justified. Policymakers need to understand a balanced approach to supply and demand as broadband adoption is more "demand-constrained" than "supply-constrained" (Shim et al., 2006).

Finally, it is worth briefly discussing that the effect of regulation on broadband penetration is not significant. Whether or not unbundled access to the local loop is required does not seem to be a critical determinant of broadband penetration. This provides further evidence to the study (Vareda and Hoernig, 2007), suggesting that the aggregate effect of unbundling on total investment is not obvious.

Chapter 6 Conclusion and policy recommendations

The empirical findings presented in this dissertation provide some useful recommendations for the design of an appropriate policy to be adopted by the public players to promote broadband penetration by investigating the effectiveness of past policies.

In this chapter, we will discuss the policy implications of the empirical results presented in chapter five. Regardless of the implications, it is noteworthy that there is no one-size-fits-all policy. Different policy strategies suit different countries with different policy objectives.

6.1. Summary of this research

The purpose of this research is to examine, both theoretically and empirically, the effect of public policy on broadband development. Public policies in the broadband market were examined by means of demand-side policies that aim to raise people's willingness to pay for broadband services and supply-side policies that aim to lower the price by subsidizing operators. The study explores the working of these two different instruments through theoretical discussion as well as econometric analysis.

Chapter three discusses theoretical considerations about government interventions. When public players decide to intervene to stimulate broadband penetration, whether to subsidize consumers through demand-side policies or support operators by means of supply-side policies becomes the focus of the debate. Each of these approaches has advantages and

limitations. Demand-side policies aiming to increase market demand are found to promote competition, while supply-side policies risk distorting market competition. Government interventions to promote broadband penetration might be more productive on the demand side than on the supply side.

The case studies show, by examining public policies and how these have shifted over time in the UK, Sweden, South Korea, and Australia, that demand-side policies were initiated at a very early stage to stimulate the demand for broadband services in Sweden and Korea, regarded as top performers in broadband provision and penetration the world over. In contrast, there was little effort to generate demand in Australia, which was well behind the OECD average for total broadband subscribers per 100 inhabitants, though broadband is widely accessible. A hypothesis is proposed based on the findings from case studies: *Broadband penetration is more likely to be demand-constrained than supply-constrained, and thus, public interventions on the demand side are much more effective than on the supply side.* This hypothesis implies that public policies allocated on the demand side work better than those on the supply side, and high demand for broadband can "pull" broadband network rollout.

In the empirical part, chapter five examined public policies in the broadband market by means of demand-side policies that aim to raise people's willingness to pay for broadband services and supply-side policies that aim to lower operators' cost of infrastructure

construction. The working of these two different instruments is analyzed. Concerns are raised about whether demand- and supply-side policies have similar effects on broadband penetration. Further, certain demand- and supply-side policies are compared to ascertain whether a combination strategy provides better performance.

It is found that only demand-side policies have a significant positive impact on the broadband penetration rate. The estimation results provide strong evidence to support H1: *(demand-side policies have a positive impact on the broadband penetration rate)* and H2: (*demand-side policies have a greater impact on the broadband penetration rate than supply-side policies).* Hypothesis H3 (*jointly adopted policies should be the most productive way of promoting broadband penetration)* is rejected by the test results.

To sum up, the estimation results of econometric analysis show that

- Demand-side policies do have a positive impact on the broadband penetration rate.
- Demand-side policies have a greater impact on the broadband penetration rate than supply-side policies.
- The combination strategy has no statistically significant influence, nor is it more effective than demand-side policies.

The analysis results indicate the importance of demand-side policies in promoting broadband penetration, considering that only demand-side policies have a significant positive impact on the broadband penetration rate. The results also showed that demand-side

policies have a greater impact than supply-side policies. It follows that countries with a competitive[24] telecommunications sector and relatively high performance ranking based on the ICT Development Index (IDI) access indicator (ITU, 2014) should focus on stimulating demand for broadband connection.

6.2. Policy implications

6.2.1. Demand-side policies

Econometric analysis shows that demand-side policies have a positive and significant influence in stimulating broadband penetration in OECD countries. Demand-side policies have two kinds of influences. First, they aim to increase the number of subscribers directly. As the dependent variable measures the adoption rate rather than broadband coverage (which measures the availability of infrastructures), demand-side policies are likely to be more effective than supply-side-policies. In addition, demand-side policies are more effective with network effects, which are crucial in determining broadband diffusion (Whitacre, 2010; LaRose et al., 2011).

Second, demand-side policies aim to increase the demand for broadband service by raising its perceived value. Demand-side policies reduce government interference on the operation of the market and enhance market competitiveness, without distorting the market.

[24]Ibid. footnote 20.

Given that inter-platform competition has a significant positive effect on broadband penetration, demand-side polices can increase broadband penetration.

A perhaps overlooked fact is that, in technologically advanced countries, a wide diffusion of Internet can encourage private investment in broadband network infrastructure. The government should emphasize broadband usage. Gillett et al. (2006, p.11) state that "once broadband is available to most of the country, differences in economic outcomes are likely to depend more on how broadband is used than on its basic availability. The implication for economic development professionals is that a portfolio of broadband-related policy interventions that is reasonably balanced (i.e., also pays attention to demand-side issues such as training) is more likely to lead to positive economic outcomes than a single-minded focus on availability." We suggest that the attention that has been historically placed on supply-side interventions should be adjusted to the demand side.

6.2.2. Supply-side policies

The study suggests that supply-side policies do not have a significant impact on broadband penetration among the 30 OECD countries. The insignificance of the supply-side policy parameter does not support the hypothesis (H1) that countries with supply-side policies to stimulate broadband penetration have a higher percentage of citizens with subscription to broadband service than countries that lack supply-side policies. Moreover, this result is inconsistent with recent findings that counties devoting more financial

resources to develop and promote information technology, telecommunications, and industries have a larger number of broadband subscriptions (Wallsten, 2005; Gulati and Yates, 2012). However, Bauer et al. (2003) and Aizu (2002) found that government funding to support broadband deployment does not have a significant influence on broadband diffusion.

What is different in these studies is that they use a more specific indicator of supply-side policies to explain the contrasting results. This is the case with certain policies that are meant to correct market failure, such as investment in backbone network construction in rural areas where no Internet access technology is available. We suppose that people's willingness to subscribe to broadband services is heterogeneously distributed in the population. Those with the highest willingness to subscribe will adopt broadband service once it is available. Thereby, supply-side policies would successfully enhance broadband penetration. However, it is also important to note that the digital subscriber line (DSL) and cable modem markets of all the 30 OECD countries have full competition[25]. Thus, the risk that asymmetric information between public players and operators could lead to market distortions should not be underestimated. Another explanation is that the estimates do not necessarily indicate that supply-side policies are not important in those 30 OECD countries, but rather that further increasing supply-side policies cannot promote broadband penetration

[25]ITU World Telecommunication Regulatory Database (see https://www.itu.int/net4/itu-d/icteye/Topics.aspx?TopicID=6).

in countries with widespread access to various information and communications technologies (ICTs). Usually, the coverage of network infrastructures evolves relatively fast in the beginning and slows down thenceforth (Eskelinen et al., 2008), while adoption increases follow a typical S-shaped diffusion curve (Rogers, 2003, p. 112), as seen in Figure 6.1. Not surprisingly, the gap between adoption and coverage of network infrastructures tend to be larger if only supply-side policies were employed by the government to accelerate infrastructure deployment, at least at the early phase of the process. Figure 6.2 shows the ideal diffusion path of broadband penetration and coverage. The dashed line represents the coverage curve if supply-side policies had a significant influence on broadband coverage. Obviously, the gap between coverage and penetration become wider (from L to L') with supply-side policies. Since there is no evidence that the coverage rate influences the penetration rate, we can say that supply-side policies contribute little to broadband penetration growth, which is consistent with the econometric results in chapter five. Thus, we conclude that governments, in technologically advanced countries, should place less reliance on supply-side policies.

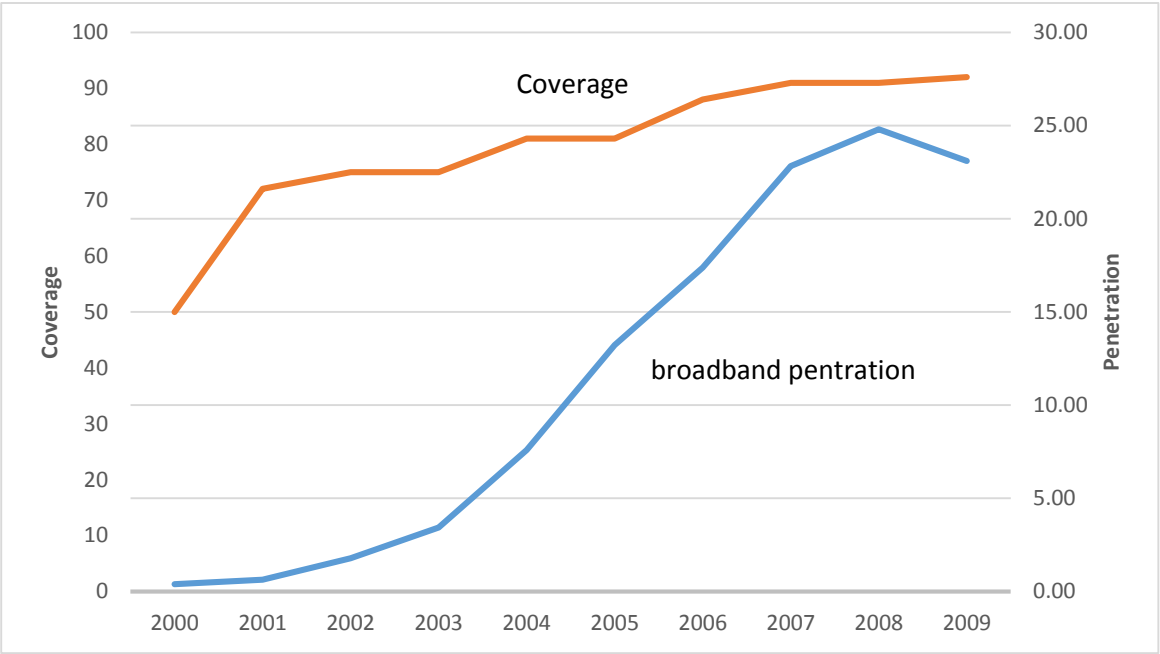

Figure 6.1 Broadband penetration and DSL coverage (population covered) in Australia

Source: Created on the basis of OECD (2014).

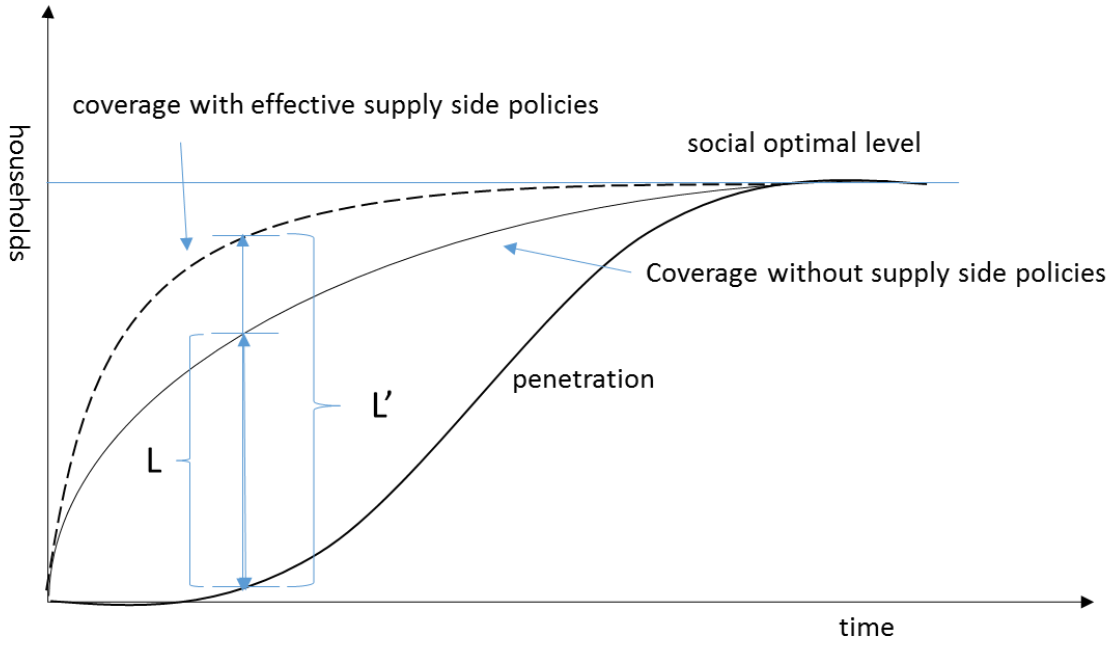

Figure 6.2 Broadband penetration and coverage

Source: Author

6.2.3. Jointly adopted policies

We have considered the synergy between demand- and supply-side policies in the empirical analysis. The results show that the synergy parameter is not statistically significant, which implies that implementing demand- and supply-side policies jointly has no extra effect. The in-depth test also provides evidence that the combination strategy has no statistically significant influence. It also shows that asymmetric information exerts a strong influence such that it could offset the effect of demand-side policies.

6.3. Policy recommendations

The results of the research provide some useful insights into broadband penetration for policymakers. As the empirical analysis is based on data for 30 OECD countries, we provide policy recommendations for countries or regions that share similar income, education, and technological development profiles[26].

6.3.1. Demand side

The empirical analysis results suggest the following government interventions to promote broadband demand:

Governments should rely more on demand-side policies to promote broadband penetration

[26]A country's level of technological development is evaluated by the ICT Development Index (IDI) access indicator (ITU, 2014).

than on supply-side polices. Demand-side policies can increase the perceived benefit of broadband for penitential users or reduce the cost of broadband subscription, leading to broadband penetration growth.

The study suggests a few specific demand-side policies:

- Governments should implement policies that encourage content and applications as well as business uses of broadband and e-commerce. Governments need to understand new usage trends and their impacts on the society and economy. Support for the evolution of advanced broadband applications (e.g., telework, education, energy, transport) in social sector requires government involvement.
- Efforts to strengthen trust in ICT use by business and consumers are required. People's distrust of technology is one of the obstacles of broadband penetration. Improvements in information security can successfully stimulate broadband penetration.
- Efforts to improve ICT and digital skills are also required. Policies should focus on the development of ICT skill and digital literacy. One of the reasons people do not connect to broadband is a lack of digital literacy, due to factors such as difficulty of use or a feeling that they are "too old to learn." It is not difficult to imagine that digital literacy among the elderly as well as those with less education and income is much less than the overall situation. Therefore,

programs to improve digital literacy should particularly target specific groups, such as the poor, the elderly, and the undereducated, in order to effectively promote broadband penetration.

Besides, income difference is one of the factors influencing broadband use. Such factors need to be better understood and addressed by the authorities. Providing subscription subsidies or tax reductions to low-income families to make the service more affordable is a direct and efficient way to promote broadband use.

We must remember that demand-side policies are based on the assumption that the broadband market is competitive and users are able to freely select the desired operator and service. As reported by ITU, the DSL and cable modem markets of all the 30 OECD countries are fully competitive[27].

6.3.2. Supply side

Empirical analysis results suggest that supply-side policies to promote broadband penetration cannot significantly stimulate broadband adoption. This implies that direct public policies on the supply side are not feasible. Direct public investment or subsidies for operators are not effective in stimulating broadband penetration. Direct public policies on the supply side should be limited as much as possible. However, this does not rule out government involvement in market supply. Rather, public policies that aim to promote

[27] Ibid. footnote 20.

market competition are facilitators for demand-side policies.

Thus, the implications of these research findings are as follows:

- Overarching involvement of government and direct public investment in the broadband market should be limited. Direct public investment might be a powerful method of government involvement. Many OECD countries have adopted supply-side policies by making direct investments for network infrastructure upgrade or FTTH network construction. However, the empirical results of this research suggest that such supply-side polices do not have a significant influence on broadband penetration. The funding provided to the operators does not necessarily result in broadband penetration growth.
- Although direct public policies on the supply side cannot stimulate broadband adoption, regulatory interventions are required. The basic aim of government intervention is to shape a competitive market structure and enhance the effectiveness of competitive markets. It is difficult for new entrants to compete with the incumbents because of economies of scale and network externalities. Therefore the government should support, to the extent possible, new entrants competing with the dominant incumbent. Thus, on the one hand, aggressive competition would lead to affordable prices, increasing broadband penetration. On the other hand, it facilitates the effectiveness of

demand-side policies by fostering a competitive market.

We have to notice that government interventions also aim to universalize broadband service, providing a baseline level of broadband service to every resident of the country. We suppose that there are certain areas (remote areas, for instance), where the population density is too low to be profitable for private operators. It is crucial that governments facilitate construction of local providers' networks.

Apart from the above recommendations for the 30 OECD countries, the results of empirical analysis also provide insights for developing countries or underdeveloped regions.

- Different policies should be framed for different regions. It is noteworthy that there is no one-size-fits-all policy. Different policy strategies suit different countries with different policy objectives. The empirical analysis results obtained in the econometric study presented here are based on data from 30 OECD countries, rather than a mixed sample of technologically advanced, developing, and undeveloped countries. It is not difficult to imagine that the results would vary for technologically undeveloped or developing countries. For instance, the above suggestions may apply to the developed regions of China, with a mature broadband market. However, for underdeveloped regions, particularly where basic telecommunications

services are not available, relying only on demand-side policies is hardly an effective strategy for broadband penetration.

- Regulatory interventions to ensure competition are suggested for developing countries as well. These are particularly important if the market is dominated by a state-owned monopoly.
- Accessibility to broadband and attractiveness of contents are important for broadband penetration, regardless of a country's development. Training all citizens to access and use Internet through digital literacy programs is an important aspect of broadband penetration.

6.4. Limitations and future research

Certain limitations of this study need to be addressed. First, the information, gathered across a number of countries, is not exhaustive. The dataset might not be fully representative because only limited information is available for some countries. Second, although this study did examine the period of the overall development of broadband penetration, it did not consider the complementary policies implemented before broadband was introduced in the market. These policies might have exerted a positive influence on broadband penetration.

Third, the regression analysis could not consider the influences of supply- and demand-side policies on price and income level, respectively, although we found that demand-side

policies have a greater impact on the broadband penetration rate than supply-side policies. We have observed that supply-side policies would decrease the price of broadband[28]. Likewise, we think demand-side policies, particularly where subsidies are provided directly to users, would increase users' income, as reflected by GDP per capita in this case[29]. This means that regression analysis cannot consider the influences of supply- and demand-side policies on price and income level, respectively. Future research should consider these influences to provide a rigorous empirical assessment of broadband policy effects.

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[28]Here, an in-depth analysis validates our observation that only supply-side policies would significantly decrease the broadband price in the next year. Regressing the price change on regulation, combination strategy, supply-side policy, and demand-side policy indexes (*Reg, D1, D2, D3*, respectively), we find only the D2 coefficient significant, with a negative impact on price change. Thus, we conclude that only supply-side policies would significantly decrease the price of broadband.

$$\Delta Price_{it} = \alpha_0 + \alpha_1 Reg_{it} + \alpha_2 D1_{it} + \alpha_3 D2_{it} + \alpha_4 \mathrm{D3_{it}} + a_i + u_{it}$$

-0.2747 0.0199 0.1850 -0.5023 -0.2332

$(0.1623)^{*}$ (0.0731) (0.1450) $(0.1801)^{***}$ (0.1937)

(Note: Statistical significance is denoted as follows: *0.1, **0.05, and ***0.01; standard errors are in parentheses.)

[29] The following estimation, where GDP per capita is regressed on *D1* and *D3*, confirms the suspicion that demand-side policies do have a significant influence on income level.

$$Ln(\mathrm{GDP}pc)_{it} = \alpha_0 + \alpha_1(\mathrm{D1}_{it}) + \alpha_2(\mathrm{D3}_{it}) + a_i + u_{it}$$

10.1163 0.2684 0.0747

$(0.0734)^{***}$ $(0.0191)^{***}$ $(0.0312)^{**}$

(Note: Statistical significance is denoted as follows: *0.1, **0.05, and ***0.01; standard errors are in parentheses.)

Fourth, because of data limitations, this study focuses only on fixed broadband technologies. The importance of mobile broadband technologies has been increasing in recent years. An empirical analysis covering mobile broadband policies needs to be conducted.

Nonetheless, this analysis of the effects of public policies provides critical insights on policy strategies countries need to consider.

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Appendix: List of policy programs concerning to chapter 5

Year	Supply side policy	Demand side policy
2001 (or pre-2001)	**Canada** Public funding for construction of broadband network (Upper Canada Networks[1]) **Japan** e-Japan strategy[2] **Korea** *KII-initiative*[3] **Netherlands** Kenniswijk[4] **Sweden** An Information Society for All in 2000[5] **UK** Opportunity for All In A World of Change[6].	**Canada** SchoolNet[30] program **Denmark** Danish school network Sektornet[31] **Iceland** The Information Society Policy of 1996[32] **Korea** National Knowledge Information Resource Management Project[33] **Netherland** Kenniswijk (Knowledge District) project[34] **Sweden** Tax reductions on computers bought[35] **UK** UK online centres was developed in 1999[36]
2002	**Australia** The 2002 Telecommunications action plan for remote Indigenous communities[7] **Italy** Broadband Task Force[8] **New Zealand** Project PROBE was developed[9] **Norway** eNorway Action Plan 2.0[10]	**France** Tax reductions on broadband-delivered services were provided[37] **Japan** e-Japan strategy[38] **Luxembourg** eGovernment strategy[39] **Turkey** E-government initiatives[40] **New Zealand** Project PROBE[41] **Norway**

Year	Supply side policy	Demand side policy
		eNorway Action Plan 2.0[42]
2003	**Austria** Broadband Initiative 2003[11] **Hungary** National Broadband Strategy[12]	**Austria** Broadband Initiative 2003[43] **Italy** ICT training programs[44] **Slovak republic** The national policy on electronic communications[45]
2004	**Iceland** Resources to serve everyone, the policy of the Government of Iceland on the Information Society 2004-2007[13] **Poland** Strategy of Informatization of the Polish Republic – ePoland for years 2004-2006[14]	**Czech Republic** e-Government policy[46] **Poland** Strategy of Informatization of the Polish Republic – ePoland for years 2004-2006[47]
2005	**Czech Republic** The National Broadband Access Policy 2005[15] **Luxembourg** La pénétration des technologies de l'information au Luxembourg[16] **Slovak republic** The National Broadband Access Policy[17] **Spain** National Program of broadband infrastructures deployment in rural and isolated areas[18]	**Germany** Training programs for SMEs employees to increase ICT skills and competitiveness[48] **Hungary** eHungary points[49] **Spain** The Avanza Plan[50]
2006	**Finland** National broadband strategy. Final report 2007[19] **Greece** The Plan for the Development of Broadband Services until 2008[20] **Turkey** The information Society Strategy for 2006-10[21]	**Finland** National broadband strategy[51] **Greece** The digital strategy 2006-2013[52] **Switzerland** e-Inclusion[53] **Belgium**

Year	Supply side policy	Demand side policy
		Policies to improve broadband access for households and individuals[54]
2007	**Germany** Broadband in rural areas of Baden-Württemberg[22] **Portugal** Technological Plan: A national strategy for growth and competitiveness based on knowledge, technology and innovation[23] Connecting Portugal: An action plan, for the Information Society, included in Technological Plan[24].	**Australia** Per-customer subsidies[55] **Portugal** E-School program[56]
2008	**France** "France Numérique 2012" (Digital France 2010)[25] **Ireland** National Broadband Scheme[26]	**Ireland**, National Broadband Scheme[57]
2009	**Belgium** Belgie: digital hart van Europa[27]	
2010	**US** Connecting America: The National Broadband Plan[2]	**US** Connecting America: The National Broadband Plan[58]
2011	**Mexico** Digital agenda[29]	

Notes:

1. In 2000, the Ministry of Energy, Science and Technology (MEST) awarded a grant of US$1.13 million for the construction of broadband network. Upper Canada Networks was formed in 2000 as a not-for-profit corporation to provide broadband to communities across the countries. ITU, 2003, "Promoting broadband: The case of Canada," (see https://www.itu.int/osg/spu/ni/promotebroadband/casestudies/canada.pdf).
2. See http://japan.kantei.go.jp/policy/it/index_e.html.
3. KII-initiative was developed in 1993. Republic of Korea, Ministry of Information and Communication (see http://www.krnet.or.kr/board/data/dprogram/598/G2-1%B1%E8%C4%A1%B5%BF.pdf).
4. From 2000, Kenniswijk was initiated by the Dutch Directorate General for Telecommunications and Post (DGTP). The infrastructure subsidy was provided in the framework of Kenniswijk. Kramer, R. D., Lopez, A., and Koonen, A. M., "Municipal broadband access networks in the Netherlands – three successful cases, and how New Europe may benefit," p. 3 (see http://dl.acm.org/citation.cfm?id=1189367).
5. Hall. M. Ministry of Industry, Employment and Communications (see http://www.oecd.org/sti/broadband/33864880.pdf).
6. The UK government established its national broadband strategy in 2001 through its white paper "Opportunity for All In A World of Change," targeting "for the UK to have the most extensive and competitive broadband market in the G7 by 2005." Department of Trade and Industry, Review of the UK Broadband Fund (see http://www.berr.gov.uk/files/file13440.pdf).
7. Australia. Australian Communications and Media Authority, Telecommunications in Remote Indigenous Communities, p. 9 (see http://www.acma.gov.au/webwr/_assets/main/lib310210/telecommunications_in_rics_2008.pdf).
8. Italy Policy environment (see http://www.oecd.org/internet/ieconomy/1952696.pdf).
9. Project PROBE Case Study, a case Study of Project PROBE, delivering broadband to rural schools (see http://www.e.govt.nz/resources/research/case-studies/project-probe).
10. See https://www.regjeringen.no/en/dokumenter/eNorway-Action-Plan-20/id422839/.
11. See https://www.rtr.at/en/inf/Breitbandstatusbericht2003/2219_BreitbandStatus_Summary_e.pdf.
12. See http://www.gkm.gov.hu/data/cms1057445/net_eng.pdf.
13. See http://eng.forsaetisraduneyti.is/media/English/IT_Policy2004.pdf.
14. Henten, A. and Windekilde, I., 2013, "Policy factors affecting broadband development in Poland." p. 92 (see http://riverpublishers.com/journal/journal_articles/RP_Journal_1902-097X_201414.pdf).
15. See www.micr.cz/files/2185/MICR_brozura_en.pdf.
16. OECD, "Broadband growth and policies in OECD countries," p. 144 (see www.oecd.org/dataoecd/32/58/40629032.pdf).
17. See http://www.vus.sk/broadband/nbbs/VUSBB_BReATH_Praha_2006_public.pdf
18. See http://www.bandaancha.es/EstrategiaBandaAncha/ProgramaExtensionBandaAnchaZonasRuralesAisladas/EnglishInformation.
19. See http://www.mintc.fi/oliver/upl615-LVM11_2007.pdf.

20. See http://www.infosoc.gr/infosoc/en-UK/specialreports/broadband_plan/.
21. Kelly, T. and Rossotto, C. M., "Broadband strategies handbook," p.47 (see http://broadbandtoolkit.org/Custom/Core/Documents/Broadband%20Strategies%20Handbook.pdf).
22. See http://ec.europa.eu/competition/sectors/telecommunications/broadband_decisions.pdf.
23. See http://www.planotecnologico.pt.
24. See http://www.ligarportugal.pt.
25. Atkinson, R. D., Correa, D. K. and Hedlund, J. A., 2008, "Explaining International Broadband Leadership," p. 273 (see http://ssrn.com/abstract=1128203).
26. See www.dcmnr.gov.ie/Press+Releases/Dempsey+Unveils+New+National+Broadband+Scheme.htm.
27. See http://www.broadbandcommission.org/Documents/publications/NationalBBPolicies.pdf.
28. See https://www.fcc.gov/national-broadband-plan.
29. See http://www.naftamexico.net/wp-content/uploads/2012/07/jun12.pdf.
30. See http://web.archive.org/web/20070224224427/www.schoolnet.ca/home/e/whatis.asp.
31. In 1993, Sektornet, a Danish school network is established. All institutions under the Ministry of Education are offered free connection to the Sektornet (see http://cordis.europa.eu/infowin/acts/analysys/products/thematic/flexwork/3-4/3-4.htm).
32. See https://www.itu.int/osg/spu/ni/promotebroadband/casestudies/iceland.doc.
33. Since 1987, government has been involved in building e-Government infrastructure, digitizing information and developing e-Government systems and services, implementing the National Knowledge Information Resource Management Project. "Broadband Policy Development in the Republic of Korea," (see http://www.infodev.org/infodev-files/resource/InfodevDocuments_934.pdf).
34. In 2001, the Kenniswijk (Knowledge District) project in the Netherland proposed a subsidy program to provide affordable broadband to users. Kelly, T. and Rossotto, C. M., "Broadband strategies handbook," p.267 (see http://broadbandtoolkit.org/Custom/Core/Documents/Broadband%20Strategies%20Handbook.pdf).
35. Swedish government introduced tax reductions on computers bought by companies for their employees' private usage in 1998. Swedish commitment to broadband both in the cities and in the countryside, p.13 (see http://www.oecd.org/sti/ieconomy/2736714.pdf).
36. See the program's description of itself at https://www.ukonlinecentres.com/about-us.
37. Iliad, 2004, "Management Report – Year Ended December 31, 2004," Iliad Corporation, Paris, France, p. 3 (see http://iliad.fr/en/finances/2004/chapitre5v8ENGLISH.pdf).
38. See http://japan.kantei.go.jp/policy/it/index_e.html.
39. eGoverenment in Luxembourg (see http://ec.europa.eu/idabc/servlets/Doc5fa7-2.pdf?id=32609).
40. Kelly, T. and Rossotto, C. M., "Broadband strategies handbook," p.328 (see http://broadbandtoolkit.org/Custom/Core/Documents/Broadband%20Strategies%20Handbook.pdf).
41. Project PROBE Case Study, a case Study of Project PROBE, delivering broadband to rural schools, (see http://www.e.govt.nz/resources/research/case-studies/project-probe).
42. See https://www.regjeringen.no/en/dokumenter/eNorway-Action-Plan-20/id422839/
43. See https://www.rtr.at/en/inf/Breitbandstatusbericht2003/2219_BreitbandStatus_Summary_e.pdf.

44. Italy Policy environment (see http://www.oecd.org/internet/ieconomy/1952696.pdf).
45. See http://www.vus.sk/broadband/nbbs/VUSBB_BReATH_Praha_2006_public.pdf.
46. See http://www.cocops.eu/wp-content/uploads/2013/10/Czech-CGov-eGovernment.pdf
47. Henten, A. and Windekilde, I., 2013. "Policy factors affecting broadband development in Poland," p. 92 (see http://riverpublishers.com/journal/journal_articles/RP_Journal_1902-097X_201414.pdf).
48. The government established programs to provide training to SME employees to increase their ICT skills and increase their competitiveness. Atkinson, R. D., Correa, D. K. and Hedlund, J. A., 2008, "Explaining International Broadband Leadership," p. c1 (see http://ssrn.com/abstract=1128203).
49. OECD, "Broadband growth and policies in OECD countries," p. 105 (see www.oecd.org/dataoecd/32/58/40629032.pdf).
50. See http://www.oecd.org/governance/public-innovation/44296202.pdf.
51. See http://www.mintc.fi/oliver/upl615-LVM11_2007.pdf.
52. See http://www.infosoc.gr/infosoc/en-UK/sthnellada/committee/default1/top.htm.
53. The Coordination Office Information Society promoted different projects to help people who would normally be excluded from the information society to acquire the skills needed to participate in the information society (see http://einclusion.ch/en/).
54. OECD, "Broadband growth and policies in OECD countries," p. 105 (see www.oecd.org/dataoecd/32/58/40629032.pdf).
55. Per-customer subsidies were provided to ISPs offering services in remote areas. Australia. Dept. of Communications, Information Technology and the Arts. Evaluation of appropriateness, effectiveness and efficiency of the program, p.18 (see http://www.archive.dcita.gov.au/2005/08/national_communications_fund).
56. See http://unpan1.un.org/intradoc/groups/public/documents/unpan/unpan039587.pdf.
57. See http://www.dcmnr.gov.ie/Press+Releases/Dempsey+Unveils+New+National+Broadband+Scheme.htm.
58. See https://www.fcc.gov/national-broadband-plan.