Inconsistent Regulation, Market Structure and Broadband Adoption in the EU: a Dynamic Model

by

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Abstract: The New Regulatory Framework (NRF) for electronic communications was intended to usher in an era of harmonised regulation across the European Union leading to better choice, price and quality for European consumers. The European Commission has voiced its frustration at the fragmented nature of the implementation of the NRF. In this paper I examine whether the NRF has indeed been introduced in a fragmented manner and whether that fragmentation affects consumers, taking broadband penetration, which is regarded as desirable both socially and economically, as the measure of consumer outcome. I find that a causal relationship exists between public policy, prices of unbundled local loops, market concentration and adoption of broadband. Using a Lagged Dependent Variable model, I find that decreasing concentration in the market structure of broadband access technologies at retail level has a strong effect on the take-up of broadband, with the effect taking time to be fully realised. To enhance consumer adoption of broadband, therefore, policy makers in the EU should seek to improve the opportunity for broadband competition.

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1. Introduction

In March 2002, the European Union adopted a set of Directives which collectively formed the New Regulatory Framework (NRF) for the electronic communications industry. These Directives were supposed to be passed into national law by the Member States by 25 July 2003.[1] The purpose of the NRF was to establish a harmonised regulatory framework and to promote competition to ensure that users derive maximum benefit in terms of choice, price, and quality. However, five years after the introduction of the NRF, there is frustration in the European Commission that these objectives have not been met due to fragmentation of the regulatory systems. In November 2007 a new set of Directives was proposed by the Commission to address some of the inconsistencies and remaining market problems. The new Directives are now subject to approval by the European Council and Parliament and transposition into national law. Therefore the electronic communications markets are still regulated under the 2002 Directives.

This paper examines the effectiveness of regulation in promoting competition in, and consumer take-up of, broadband access in the EU. In particular I examine how the key policy of Local Loop Unbundling (LLU) has promoted competition in the wholesale broadband market and how competition in wholesale broadband markets promotes broadband adoption.

I find that there are differences in regulatory policy across the EU, in particular with regard to prices for LLU and state ownership. I also find that there are significant differences in the structure of broadband markets and that change in market concentration has a strong and significant effect on the take-up of broadband.

The paper is organised as follows: Section 2 sets the scene by briefly describing key aspects of the NRF and the European Commission's frustration with progress. Section 3 reviews previous literature on the causal link between competition and broadband penetration. Section 4 briefly describes the various

[1] May 2004 for the New Member States.

broadband technologies. Section 5 examines the regulatory policies adopted by selected EU Member States and produces a cluster analysis of countries based on their market structure. Section 6 describes the models I have produced to test my expectation that competition has a strong influence on broadband adoption. Section 7 concludes.

2. The European Policy Framework

In 1999 the European Commission began an extensive review, known as the 1999 Review, of electronic communications regulation. The outcome was a set of five Directives,[2] collectively known as the New Regulatory Framework (NRF), which were adopted by the European Parliament and Council in March 2002, and scheduled to be passed into national law by 25 July 2003.

The Framework Directive sets out the objectives both of the NRF and of each Member State's National Regulatory Authority (NRA).

Article 1 states:

> This Directive establishes a harmonised framework for the regulation of electronic communications services, electronic communications networks, associated facilities and associated services. It lays down tasks of national regulatory authorities and establishes a set of procedures to ensure the harmonised application of the regulatory framework throughout the Community.

Article 8.2 states:

> The national regulatory authorities shall promote competition in the provision of electronic communications networks, electronic communications services and associated facilities and services by inter alia:
> (a) ensuring that users, including disabled users, derive maximum benefit in terms of choice, price, and quality;
> (b) ensuring that there is no distortion or restriction of competition in the electronic communications sector;
> (c) encouraging efficient investment in infrastructure, and promoting innovation

[2] Framework Directive, Access and Interconnection Directive, Authorisation Directive, Universal Service Directive, Privacy and Electronic Communications Directive. All available at http://ec.europa.eu/information_society/policy/ecomm/todays_framework/overview/index_en.htm

Competition as a means of delivering consumer benefits was therefore central to the policy and should be applied throughout the European Union.

Under the NRF, national regulators were required to carry out *ex ante* market reviews of 18 electronic communications markets as listed in European Commission 2003. The list of recommended markets was updated in November 2007 (European Commission, 2007) and reduced to seven markets deemed susceptible to *ex ante* regulation. Market reviews follow the standard competition law principles of defining the relevant market and determining whether one or more firms individually or jointly have Significant Market Power (SMP), which equates to the competition law concept of dominance. In contrast to normal competition law, the NRF requires that if one or more firms are found to have SMP at least one behavioural remedy must be imposed on the SMP operator(s). Structural remedies are not available under the NRF.

Two of the seven markets are relevant for this paper: wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location and wholesale broadband access, commonly referred to as Markets 4 and 5 respectively (previously Markets 11 and 12), due to their place on the list of seven markets. Market 4 is a wholesale market for Market 5, in that buyers of unbundled access form part of the wholesale broadband access market even if they are self-supplying their own retail activities. In all cases,[3,4] NRAs have found the incumbent operator to have SMP in markets 4 and 5, with the exception of the Netherlands where no SMP was found in market 5.[5]

The European Commission (EC), through what are known as “Article 7 Procedures” has the right to veto market definitions and findings of SMP, but may not veto remedies imposed.

[3] In all cases I refer to the new market numbers even though reviews prior to November 2007 would have referred to the old market numbers.
[4] At the time of writing, Belgium had yet to review Markets 4 & 5 and Malta has yet to review Market 5.
[5] The UK is currently completing its second review of Market 5 and has proposed that BT has SMP in some areas of the country and that no firm has SMP in other areas.

Despite the aims of the NRF, there is much evidence that Member States have adopted it with varying degrees of enthusiasm (ECTA, Jones Day, SPC Network 2005, 2006). Only five countries (Denmark, Finland, Ireland, Sweden and the UK) met the 25 July 2003 deadline. Since then, Germany has been in dispute with the European Commission over its desire to grant Deutsche Telekom forbearance from regulation over the introduction of higher speed broadband infrastructure, as I discuss later in this paper. The frustration of the European Commission became evident in January 2007 in a speech by the Commissioner for Information Society, Viviane Reding, to the European Regulators' Group (ERG). She said:

> First let me stress that in the electronic communications sector, two decades after we started to open national markets formerly dominated by state-owned monopolies to competition, we still do **not** have an internal market for telecoms. The reason for this is mainly a regulatory one: the fragmentation of the internal market into 27 different regulatory systems. [author's emphasis] (Reding, 2007)

In the speech, Reding repeated her call, first made at an ECTA (European Competitive Telecoms Association) conference in December 2006, for the EC to have greater powers to enforce regulatory consistency across the Union. One such power Commissioner Reding is seeking is the ability to veto remedies. These additional powers are set out in the proposed new Directives published in November 2007.

If, as Commissioner Reding claims, regulatory systems are fragmented, is this visible in the market place? Can we see different levels of competition resulting from regulatory policy with different consumer outcomes? To explore these questions, I examine broadband markets in Europe taking the level of take-up of broadband services as the measure of consumer outcome.

The wide availability and usage of broadband[6] internet access is central to the EU's drive for increased productivity and growth, first articulated at the European Council meeting in Lisbon in 2000, and given new impetus in 2005

[6] Defined as technologies that allow high bandwidth data transmission (high-speed) and always-on access to the internet and other electronic services.

with the “i2010 policy” adopted by Commissioner Reding. Specifically, the i2010 policy stresses the importance of broadband “to deliver rich content such as high definition video” and to contribute to the goal of social inclusion in particular in under-served areas (European Commission, 2005, p4-5).

The EU encourages all Member States to develop a national broadband strategy. The UK first adopted such a policy in 2001 and issued an updated policy in 2004. The UK government’s ambition was to have the most extensive and competitive broadband market amongst the Group of Seven leading industrialised countries by 2005. It considered this necessary as broadband was expected to deliver hard economic benefits, but also social advantages, in particular:

- “greater lifestyle choices for people as, for example, home-working possibilities increase;
- improved public service delivery through transformation of the public sector and increased access for citizens to on-line education and health services;
- substantial new opportunities for digital content providers to commercialise new products in the ever-expanding digital space. With its strong media and computer games industries, this is an area where the UK has the potential to benefit.” (DTI, 2004)

Despite the faith placed in broadband by policy makers, it was not until recently that academics and researchers have been able to use hard data on actual broadband deployment and economic development to conduct a proper empirical analysis and calculate the economic benefits of broadband. Lehr et al (2006) at the Massachusetts Institute of Technology have estimated the effect of broadband on a range of economic measures: employment, wages and industry mix in the US, using a cross-sectional panel data set of communities (by zip code). The study compares the variables of interest in 1999 and 2002. They find support for the conclusion that broadband positively affects economic activity.

Lehr et al employ regression analysis which measures the change in the economic variable of interest (e.g. employment) and uses control variables for differences in community characteristics and a dummy variable for whether broadband was available in the community in 1999 or not. The equation generally takes the form:

$$Y(t) = a + \alpha Y(0) + X\beta + \gamma BB + e$$

Where:

- Y(.) is the economic variable of interest, for example the share of establishments in IT intensive industries
- X are the control variables for differences in community characteristics of the different zip codes
- BB = 1 if the community had Broadband in 1999 and 0 otherwise; and
- e are the error terms.

They interpret γ as the impact of broadband on the level of change in dependent variable Y(.) over the interval [0,t]. The results of the study are summarised below:

- Employment increased by almost 1.5% in areas with broadband since 1999;
- There is no discernable effect on wages;
- The number of business establishments increased by almost 0.5%; and
- The share of firms in IT intensive sectors is higher in broadband communities and increased by an additional 0.5% between 1998 and 2002.

Lehr et al conclude that “the most obvious and important implication is that broadband *does* matter to the economy” (their emphasis) and that “broadband is clearly related to economic well-being and is thus a critical component of our national communications infrastructure”.

This early empirical evidence appears to lend support to EU policy makers’ belief that broadband delivers discernable economic benefits.

3. Literature Review

Since the move away from nationalised industries and towards privatisation and competition during the 1980s and 1990s, international policy organisations have been strong supporters of competition. The Organisation for Economic Co-operation and Development (OECD), for example, has consistently argued in favour of competition at the level of the local loop, i.e. between access infrastructure providers rather than simply retailers of incumbent operators' wholesale products. It has also argued that availability of broadband will not automatically translate into demand unless prices are affordable, and that competition is the best way to ensure attractive pricing (OECD, 2002, 2003).

There is a general consensus in the academic literature that competition is a driving force of broadband penetration. However, most of the literature is now relatively old, in relation to the broadband market, and so the empirical studies relied on data at an early stage in market development.

Howell (2002) was one of the first authors to use empirical evidence to determine whether a policy of promoting Local Loop Unbundling (LLU) helped stimulate the take-up of broadband in OECD countries and in particular Australia and New Zealand. She first postulates that:

> "..the success measures of telecommunications market regulatory policies on competitiveness in downstream markets are not necessarily to be found in measures such as investment in the telecommunications sector, or even in the numbers of provider participants in the market. Rather the measures of success of such policies (if they exist) will be evidenced in the availability, prices and uptake of services in those downstream markets."

The core of Howell's thesis is that competition between broadband platforms, in particular between cable and Digital Subscriber Lines (DSL) is the main driving force of broadband penetration. Using data from June 2001, very soon after broadband was launched in most OECD countries, she shows that there is a strong correlation (R^2 = 0.63) between the penetration of cable models and DSL across the OECD and that this correlation is stronger (R^2 = 0.80) when the then two most developed markets (New Zealand and Korea) are excluded. She concludes from this that “duplicate infrastructures (albeit of different technology bases, but performing the same function in some cases) appear to be having a much greater impact upon promoting the uptake of broadband services than local loop unbundling”.

This central claim is supported by the consultancy company Dotecon (2003) in a paper prepared for the Brussels Round Table, a lobbying group of incumbent telecommunications operators and equipment suppliers. Dotecon draws a distinction between facilities-based and access-based competition. Facilities-based competition refers to the presence of two or more independent platforms (e.g. DSL and cable) whereas access-based competition requires service providers to have access to the infrastructure of the dominant operator. They find that facilities-based competition “leads to competition over more aspects of a service that access-based competition, and is self-sustaining”.

Using data from the OECD, Dotecon find an inverted U relationship between total broadband subscribers and non-DSL market share. As the market shares of cable and DSL move towards 50% each, so broadband penetration increases, whereas penetration is lower when one of the two technologies dominates.

Also drawing on OECD data, Bauer et al (2003) develop an econometric model to examine the drivers of broadband penetration. The model uses international cross-section data for the year 2001, when broadband had only just become available in many OECD countries. Their model uses broadband penetration, defined as the number of DSL, cable and other broadband subscribers as a percentage of the total population, as the dependent variable. Price of broadband, price of dial-up, income, national preparedness, competition, population density and a dummy variable to represent policy regimes are used as the explanatory variables. They base their measure of competitiveness on the competitive conditions in DSL, cable, and the Internet Service Providers (ISP) sectors taken from Arquette (2002) though they do not elaborate on how Arquette quantifies competition.

Bauer et al point to a potential endogeneity problem between competition and price in that more intense competition may lead to lower prices.

In the results of their models they find that competition does not have a statistically significant effect and that the effect it does have is negative, suggesting that penetration is higher in more concentrated markets. They note that this finding contradicts other studies. They suggest the reasons for this contradictory finding may be that competition is a local phenomenon and not easily captured at local level and that the effect of competition may also be captured in the price variable. Their third suggestion is that it could also point to an “oligopolistic structure of broadband in which a more open market structure could lead to market fragmentation and lower deployment”.

It may also be that the study was conducted at too early a stage in broadband development such that there were too few consumers to produce reliable results.

Distaso et al (2004) developed a model of broadband platform competition and adoption using data from 14 EU countries. Like Bauer et al, their models seek to explain broadband penetration, but their definition of penetration is different. Distaso et al define broadband penetration as broadband lines as a percentage of total access lines in the country. They developed three models of leased line prices, prices of unbundled copper loops, competition within the DSL platform, competition between different platforms, policy related to rights of way and local call prices as the explanatory variables. They use annual data across three years from 2001 Q2 to 2003 Q2.

All their models show competition between platforms to be significant at 95% and competition within DSL to be non-significant.

Cava-Ferreruela and Alabau-Muñoz (2006) divide OECD countries into three groups according to their approach to broadband policy. The first group have “soft-intervention strategies” characterised by low government involvement in broadband infrastructure deployment and includes the UK, Switzerland, Denmark and New Zealand. “Medium-intervention strategies” include both supply-side actions to assist in the establishment of broadband networks and demand-side action to promote broadband service adoption. This group includes countries with a tradition of state involvement, such as France and Sweden. The third group of countries, which includes Korea, Norway and Singapore, have “hard-intervention” strategies characterised by very proactive government involvement in broadband infrastructure.

In their regression models Cava-Ferreruela and Alabau-Muñoz begin by examining the drivers that affect DSL and cable coverage separately. They then produce separate models of DSL and cable broadband adoption, defining penetration as DSL subscribers per 100 population and cable subscribers per 100 population respectively. The authors find that soft-intervention strategies that promote technological competition (between cable and DSL) are most effective at promoting broadband supply. However, they find that such strategies need to be complemented by medium-intervention strategies to serve uneconomic areas.

Cava-Ferreruela and Alabau-Muñoz point out that the limitations of the empirical analysis do not allow a determination of whether any of the considered policy initiatives are necessary or sufficient to facilitate broadband supply and demand. They do not, however, consider whether there is any endogeneity between the effects of soft intervention strategies and broadband take-up. It may be possible that governments do not need to intervene in the market to promote broadband where take-up is strong and so may adopt soft strategies.

This paper builds on the work reported above in a number of ways: first it uses a longer time series from 2002 Q3 to 2006 Q3. Secondly, I do not confine myself to looking at competition only between DSL and cable or within the DSL platform, but across all forms of broadband access. The more contemporary data allows me to include local loop unbundling as a half-way house between intra-platform competition and facilities-based competition. I also introduce the price of unbundled local loops as a demand-side variable. The longer time series also allows me to develop a dynamic Lagged Dependent Variable (LDV) model and so calculate both the short- and long-term effect of market structure of broadband adoption.

This paper's principal contribution to the literature is that it explores a causal relationship between state ownership, prices of unbundled local loops, market structure and broadband adoption. I examine how a state's ownership of the incumbent may negatively affect its desire to see lower prices of unbundled local loops thereby raising barriers to entry and maintaining a more concentrated market. In common with the authors cited above, I then explore the relationship between market structure and broadband adoption.

4. Broadband Access Technologies, Wholesale and Retail Levels

Throughout this paper I analyse the broadband market with reference to five different broadband access platforms. I also refer to both the wholesale and the retail markets. Each term is defined below.

Retail The retail market is the furthest downstream market selling to residential and business consumers of broadband access. It consists of Internet Service Providers (ISPs).

Wholesale Wholesale broadband access is the provision of broadband access from an upstream provider to the retailer. In many cases the upstream provider will be vertically integrated with the retailer and therefore the wholesale market is characterised by self-supply. However, there is also generally some, albeit limited, external supply of broadband access.

Incumbent The incumbent is the former state monopoly in each EU Member State, for example France Telecom in France. Each incumbent has its own ISP at the retail level. Orange, formerly Wanadoo, is France Telecom's ISP in France and elsewhere in Europe.

Bitstream Retail ISPs which do not possess their own access network resources are reliant on purchasing wholesale inputs from the incumbent. The European Regulator's Group (ERG) refers to three varieties of bitstream: types 2 (simple resale[7]), 3 (IP[8] bitstream) and 4 (ATM[9] or equivalent bitstream). These products are collectively referred to as bitstream. As retailers move from type 2 to type 4, they require more investment in their own capital equipment. The bitstream products consist of both the copper cable running from the exchange to the customer premises and the electronics attached to those cables at the exchange end to provide broadband access.

Local Loop Unbundling (LLU) This access method uses the incumbent's copper access line from the exchange to the customer premises, but the LLU Operator (LLUO) provides its own electronics at the exchange to enable the local loop for broadband. It is currently generally considered to be the deepest level of the network at which competition is possible given that duplicating the incumbent's copper access network would be prohibitively expensive.

Incumbent operators, resellers of bitstream access and LLUOs all use a technology known as Asynchronous Digital Subscriber Lines (ADSL) which is a way of getting higher data speeds over the copper network. Currently, the most advanced form of ADSL is ADSL2+ which can provide data rates of up to 24 megabits per second (dependent on the distance from the exchange to the customer premises), enough to run High Definition TV.

[7] Strictly speaking simple resale is not bitstream but for ease of labelling it is referred to as such in this paper.
[8] IP – Internet Protocol.
[9] ATM – Asynchronous Transfer Mode.

Local loops have two frequency bands. The low frequency band carries voice and the high frequency band carries data. This gives rise to two forms of LLU: Fully Unbundled Loops have both the high and low frequency bands unbundled so that the LLUO can offer both voice and broadband. Partially Unbundled Loops consists of just the high frequency band for data only.

Cable Cable is a separate access network generally not owned by the incumbent operator (except in Portugal). Cable was originally used to deliver television but in some countries it has been upgraded to offer narrowband and broadband access.

Other This is a catch-all for any other type of broadband access technology and includes fibre to the home (FTTH) and wireless. In some countries, e.g. Sweden and Italy, there are pockets of FTTH whereas wireless is more prevalent in some of the new Member States.

5. Regulation and Competition in EU Broadband Markets

In this section I briefly describe the history of broadband development and regulatory policy in selected EU Member States: the Netherlands, Sweden, France, Germany and the UK. These countries have been selected as they represent a cross-section of the approaches taken in the EU as a whole. At the end of this section I cluster the 25 Member States by market structure.

5.1 The Netherlands

The copper local loop, over which DSL services are provided, is owned by KPN, the former state owned and vertically integrated monopoly. Over the past ten years or so the government has progressively sold its stake in KPN and the company is now fully in the private sector.

The Dutch regulator, Onafhankelijke Post en Telecommunicatie Authoriteit[10] (OPTA), is an independent executive body, a status that enables it to operate at a distance from the Ministry of Economic Affairs. It reports to the Ministry, rather than to the legislature as is the case in some other countries. Its costs of operation are recovered from the industry in the form of fees for specific resources, e.g. licences, spectrum etc. Independence from government is further protected by the inability of any body, other than the courts, to overturn an OPTA decision. This contrasts with the position in Belgium, for example, where the Council of Ministers can overturn the regulator's decisions. OPTA has three board members (OECD, 2006).

In common with other EU countries, KPN offers local loop unbundling (LLU) which has been made compulsory by the regulator, OPTA. Prices for both initial connection charges and monthly rental of fully unbundled local loops (voice and data) are below the EU average, as are prices for partially unbundled loops (data only). Despite the relatively low price, the market share of LLU in the Netherlands is in line with the mean for the EU, though twice as high as the median.

Resale of the incumbent's wholesale broadband access service (collectively known as bitstream) is very low in the Netherlands, at less than 1% of the market compared with an EU average (mean) of 12.4%. This is because there is no obligation on KPN to provide bitstream access. OPTA had originally intended to prescribe bitstream, but in several legal proceedings between OPTA and Tiscali (a broadband ISP demanding bitstream access) against KPN the courts found that the then prevailing telecommunications law did not provide the legal basis for bitstream access (CPB, 2005). Consequently, potential competitors to KPN need to invest in their own infrastructure. However, the strong presence of cable, which existed before KPN launched a DSL service, and the below average penetration of LLU and other access technologies suggests that most firms have not invested in alternative access technologies.

[10] Independent Post and Telecommunications Authority.

Since the original decision, the New Telecommunications Act 2004 has come into force to implement the New Regulatory Framework (NRF) from the EU. Under this Act, OPTA has conducted a review of the market for wholesale broadband access which it divided into two grades of service: “low quality” and “high quality”. Following a review of Market 12, OPTA found no SMP existed in the market for “low quality” (defined as a booking ratio of more than 1:20), and so could not require KPN to offer such a product.

The primary competition to KPN’s broadband ISP is the cable sector. The Netherlands has a developed cable TV network serving 90% of the country which has historically been used for the delivery of “free to air” TV channels. The cable network was easily upgraded to be broadband capable and so cable was the first form of broadband access in the Netherlands. Indeed, until 2004, cable had a greater penetration than all DSL combined and was only overtaken by KPN’s DSL service during 2004 (OPTA, 2006). This has meant that the retail market for broadband has been found by OPTA to be effectively competitive and therefore free from *ex ante* regulatory remedies. The wholesale broadband market has also been found to be competitive.

Around 60% of the cable network is privately owned by private equity or the international cable operator, UPC. The remaining 40% is either publicly owned by local government or by not-for-profit organisations.

The strong position of cable broadband access in the Netherlands appears to have happened by chance rather than as a result of any specific policy initiative by either the government or the regulator. This contrasts with the situation in the United Kingdom, where cable-based competition was originally promoted by public policy, though this was later played down.

5.2 Sweden

The Swedish incumbent operator, TeliaSonera, is the result of a merger between the former Swedish incumbent (Telia) and its Finnish counterpart (Sonera). The Swedish government retains a 45.3% share in TeliaSonera, with the Finnish government holding 13.7%. The same government department which holds the share is also responsible for controlling the national regulator, *Post-och telestyrelsen*[11] (PTS), which is a government agency rather than an independent regulator.

PTS reports to the Ministry and is jointly funded by contributions from the industry, fees for resources and from central government budget. Appropriation of funds from central government provides another channel through which the government can influence the regulator. PTS has a large board consisting of nine people appointed by the government. Only the courts can overturn PTS's decisions (OECD, 2006).

In Sweden, the principle competition to the incumbent is split between cable and other forms of infrastructure, primarily fibre-based Local Area Networks (LANs), often provided by municipalities.

Sweden has a long history of public sector involvement in competing broadband infrastructure. The City of Stockholm founded its own company, AB Stokab, in 1994 to invest in dark fibre infrastructure to promote economic growth in Stockholm. The company does not act as a service provider to end users, but sells wholesale capacity to retailers on a competition-neutral basis. AB Stokab is far from the only municipality owned fibre infrastructure in Sweden. There are 265 members of the Swedish Urban Networks Association. Although not all are providers of networks, such a large membership list indicates the extent of alternative access providers in Sweden.

The principal individual competitor to TeliaSonera is B2 which provides high speed Ethernet and VDSL connections to households.

The infrastructure-based competitors to TeliaSonera are able to offer substantially higher access speeds than are available on ADSL. This means that although the overall penetration of broadband in Sweden is less than some other EU countries, a higher proportion of consumers have higher speed connections (Broadband Wales Observatory, 2005a).

[11] National Post and Telecom Agency

The development of municipal networks offering fibre-based services has been a deliberate government policy, in some cases using government funds to invest in the infrastructure. Issues relating to state aid have been avoided by ensuring that the fibre networks are open to all retail service providers.

In the first quarter of 2006, LLU accounted for approximately 4.5% of broadband connections in Sweden, about the same as in the Netherlands, but nearly double the proportion of a year earlier. This reflects a growth from just under 30,000 lines in 2005 Q1 to just under 80,000 lines in 2006 Q1.

Sweden has always had the least concentrated market, at an inter-platform level. Its inter-platform Herfindahl-Hirschmann Index (HHI) was 2,837, against an EU average of 5,780, in 2002 Q1, and was 2,445, against an average 4,179 in 2006 Q1. The decrease in its market concentration has been substantially less therefore than in other EU countries.

5.3 France

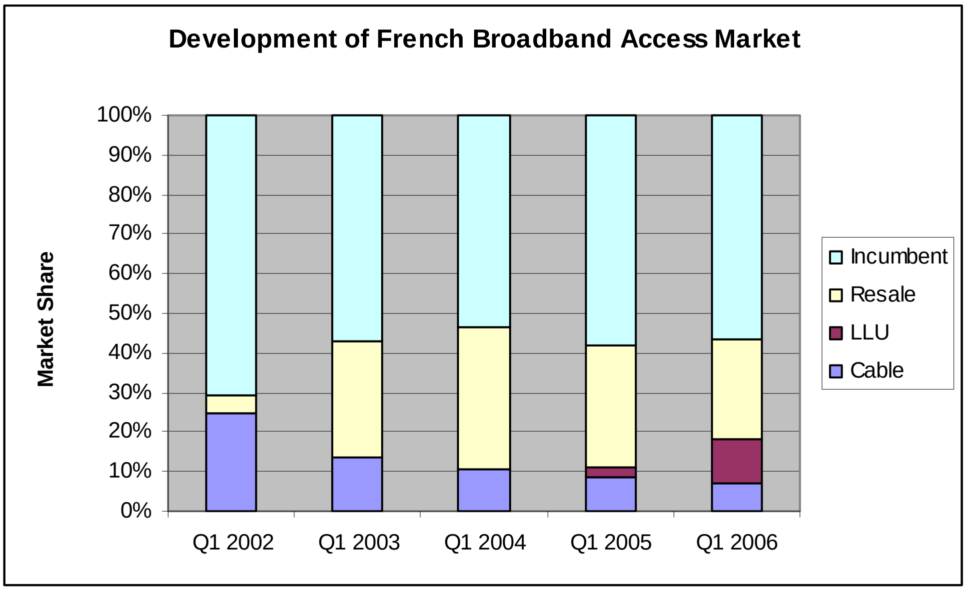
The French government also retains a significant shareholding in the incumbent operator, France Telecom, though this has been reduced in recent years. In 2002, the government held 56.5% of shares which was reduced to 32.5% by June 2005. This level of shareholding is below the blocking threshold (33.3%).

The French regulator, Autorité de Régulation des Communications électroniques et des Postes[12] (ARCEP) is, in law, fully independent of government. It reports annually to both the government and Parliament. ARCEP's decisions may only be overturned by the courts. However, its costs of operation are provided by central government which, combined with the government's shareholding in France Telecom, may be regarded as placing a limit on its independence. ARCEP has a seven member board appointed by the President of the Republic, the President of the National Assembly and the President of the Senate.

[12] Regulatory Authority for Electronic Communications and Posts.

France has seen a marked shift in the competitive landscape in the recent past from cable, to retailers of the incumbent's bitstream product to LLU.

Figure 1: Development of the French Broadband Market



Data source: ECTA

ARCEP's predecessor, Autorite de Reglementation de Telecommunication[13] (ART), was inspired by the success of broadband in Asian countries and in particular Japan and Korea. It therefore introduced aggressive policies on access in 2002 to ensure competitors had low cost access to France Telecom's bottleneck facilities (Krafft, 2006). Since 2004 the proportion of consumers using fully unbundled loops has grown from 0.1% to over 11%. This change is in part driven by regulation. The regulator has been aggressive in ensuring low prices for unbundled loops and for related facilities, such as facilities sharing and backhaul. It has also required France Telecom to publish quality of service information and to offer a proper migration procedure from bitstream access to LLU to facilitate consumer switching.

Competitive ISPs have taken full advantage of LLU to offer distinctive services. Residential users have been able to access Video on Demand (VOD) and TV over broadband since 2004, making France one of the first countries in Europe to have commercial TV over broadband (Broadband Wales Observatory,

[13] Telecommunications Regulation Authority.

2005b). The advantage that ISPs gain from the use of LLU, as opposed to bitstream access, is that they place their own equipment, known as DSLAMs,[14] in the exchange. This allows the ISPs much more control over the quality of service and speed of access they provide to their customers. They also have more control over price as they need only pay for the copper local loop rather than active electronic services. As a result, French consumers can get access speeds of up to 24 mbit/s using ADSL2+.

In September 2006, the French company Iliad, which operates under the brand name "Free", announced that it was investing in a fibre to the home (FTTH) network around Paris[15] which would make Paris the first European capital to have fibre access to the Internet.

5.4 Germany

The German government holds 30% of Deutsche Telekom's shares: 14.62% by the Ministry of Finance and 16.63% by the German Recovery Bank, which is underwritten by the government if it sells shares at a loss and must pass any gain over to the government. The government is entitled to representation on the Supervisory Board.

The regulator, Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen[16] (BNetzA), was formed in July 2005 when the previous telecommunications regulator was subsumed into the wider network industry regulator. Its work falls under the Federal Ministry of Economics and Technology, providing at least partial separation from the Ministry holding Deutsche Telekom's shares. BNetzA reports to the legislature every two years. It is funded by a combination of fees, contributions from the industry and central government. BNetZa is headed by a President and two Vice-Presidents. Only the courts may overturn its decisions.

Germany also sees most competition coming from LLLU. However, in recent years there has been a strong protectionist move to defend Deutsche Telekom

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[14] Digital Subscriber Line Access Multiplexers.
[15] Press Release: *Free launches fibre-to-the-home (FTTH) roll-out*.
[16] Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway.

(DT), the incumbent, from competition in higher speed broadband markets using fibre to the cabinet and VDSL[17] for the final connection from the cabinet to the consumer. DT claimed that the market for high speed broadband access was a “new market” and therefore exempt from the *ex ante* regulation of the NRF as transposed into German law. DT argued to the government and the regulator that if high speed broadband was included in the wider broadband access market which would be likely to result in a finding of SMP on DT with subsequent price controls, it would have no incentive to make the necessary investment.

Deutsche Telekom found considerable sympathy for its argument within the government which was ready to pass a new law granting Deutsche Telekom the regulatory holiday it called for. However, the European Commission was vehemently opposed to such a course of action and made it clear that it would be ready to launch infringement proceedings against Germany if it passed the law which it believe breached the NRF Directives. On 26 February 2007, the Commission launched “fast track” proceedings against Germany to prevent such regulatory holidays.[18]

An apparent anomaly in Germany is the low share of the broadband access market enjoyed by cable: 2.4% against an EU average of 21.1%. This is even more peculiar when one considers that 56.4% of all households in Germany receive broadcast TV via cable (Schulz et al, 2002). To understand the reason for this requires a brief look at the history of German broadcasting. During the National Socialist period (1933–1945) broadcasting was used as a propaganda tool. So, after the end of the war, Germany wanted to see broadcasting as an instrument of society rather than the state and set up different broadcasters in each of the states. Only in 1963, by an interstate treaty, was a national broadcaster established (Schulz et al, 2002). Germany also wanted to ensure that broadcasting was pluralistic.

[17] A variation of DSL which gives very high speed access over copper. VDSL requires a short line length and so DT is seeking to expand its fibre network from the exchange to the street cabinet, thus shortening the distance to customer premises.
[18] European Commission Press Release *Commission launches "fast track" infringement proceedings against Germany for "regulatory holidays" for Deutsche Telekom* 26 February 2007.

A distinctive feature of the German cable infrastructure is its division into four network levels which is enshrined in the law and designed to protect citizens from excessive state control of TV. Level 1 comprises programme production, level 2 transmission, level 3 the backbone network and level 4 the access network. To provide Internet access, the level 3 operator is dependent on the co-operation of level 4 operators which is made more difficult due to the fragmentation of the market at level 4 (Vanberg, 2002).

This structure effectively destroys the opportunity for vertical integration efficiencies. German cable operators have therefore lagged behind their peers in other EU countries in making the necessary investments to upgrade their networks to be capable of providing broadband access (Hazlett, 2006, WIK, 2006). Consolidation, in particular between level 3 and 4 operators, could also save time and resources allocated to negotiations (Vanberg, 2002).

5.5 United Kingdom

BT, the UK incumbent operator, is 100% owned by the private sector. The government does not even retain a "golden share".

The regulator, Ofcom,[19] is an independent body which reports to Parliament and is funded by fees, appropriation and contributions from operators. Only the courts may overturn its decisions. Ofcom is run by a nine member board appointed by the Secretary of State for Trade and Industry.

The UK's approach to stimulating competition in broadband access has been through three phases. Initially, UK policy makers saw infrastructure competition via cable as the main competition to BT. In 1987 Windsor Telecom, a cable TV franchisee, obtained a determination from the then regulator (Oftel) which allowed it to provide telephone services, albeit in conjunction with Mercury, the only licensed competitor to BT at that time. It was not until July 1993 that the first group of cable TV franchisees was granted licenses to offer voice telephony in their own right.

[19] Office of Communications.

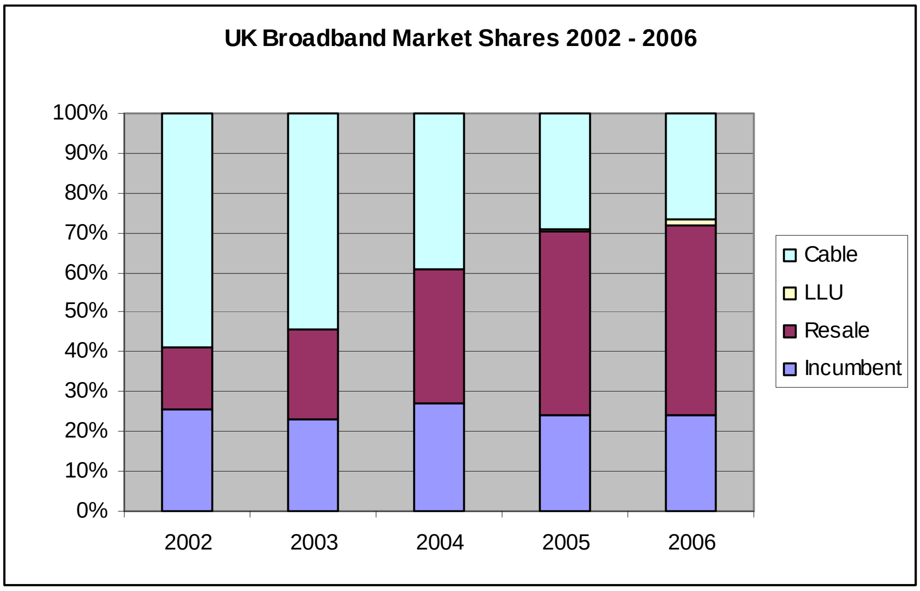
BT launched its commercial ADSL service in July 2000, one month later than the median for the European Union. Although there is no publicly available concrete evidence, the generally accepted view of the industry is that BT's roll-out of DSL mapped onto the cable footprint, which was also being upgraded to provide broadband services. Similarly, BT's prices responded to pressure from cable companies, as did the access speeds at which broadband was offered (Blowers & Cadman, 2003).

From the launch of broadband in 2000 until the summer of 2002 the two remaining cable operators (ntl and Telewest) were outselling BT. After then, however, the market share of BT began to rise at the expense of cable. At the same time, cable companies faced financial difficulties (both firms taking protection from creditors under Chapter 11). The regulatory emphasis began to switch from independent infrastructure competition to service-based competition using bitstream access, the second phase of regulation.

Figure 2 shows the progression of the market shares of the four primary broadband access modes in the UK. Internet Service Providers reselling BT's wholesale products have steadily increased their share from 15.6% at the start of 2002 to 48% by 2006. Within this sector, there is intense competition. The European Commission reports that there are 780 resale agreements in the UK: more than the rest of the EU combined (European Commission, 2006, Annex II, Table 1).

However, the limitation of resale is that retailers are unable to introduce any product differentiation as all are reselling essentially the same underlying product. They can only compete on price by having a more efficient sales operation or by building value in the brand. Ofcom recognised this problem and in 2006 introduced new, more aggressive LLU regulations following a review of the Wholesale Local Access Market in 2005 (the third phase of regulation). At the start of 2006 there were around about 142,000 fully unbundled lines and a further 213,000 partially unbundled lines. By the end of 2006, there were over one million unbundled lines in total (OTA, 2006). Figures are not available to show how many consumers of LLU have been switched from resale, but it is expected that they form the majority.

Figure 2: UK Broadband Market Shares 2002–2006



Data Source: ECTA

5.6 Market Structures

The brief country profiles above show how different countries have arrived at different market structures for their broadband industries. Using market structure data at 2006 Q3, I have run a k-means cluster analysis which divides the countries of the EU into five clusters (column F in Table 1). Cluster 1 is those countries where cable is the principal competitor to the incumbent's ISP. Cluster 2 contains those countries where the incumbent's ISP retains a high market share and does not face strong competition from any particular broadband platform. Cluster 3 is formed of countries where the principal competitors use "other" technologies for broadband access, principally wireless. Cluster 4 contains those countries where ISPs using LLU are the main competitor. Cluster 5 contains those countries where ISPs using some form of bitstream access are the main competitor to the incumbent's ISP.

There are some anomalies in these clusters. For example, Italy (cluster 4) has a higher market share for the incumbent that Finland (cluster 2). This can be explained by the relatively even degree of competition the Finnish incumbent faces from both LLU and cable, whilst the Italian incumbent faces stronger competition from LLU and none from cable.[20] Likewise, in the UK cable has a higher market share than in either Sweden or Spain which are both in cluster 1. However, BT's competitors make much more use of bitstream than in either of the other two countries.

Table 1: Broadband Market Structure in EU25

	A	B	C	D	E	F
	Incumbent	Resale	LLU	Cable	Other	Cluster
Austria	37.5%	8.5%	14.7%	37.4%	1.9%	1
Belgium	52.8%	15.2%	1.6%	30.3%	0.0%	1
Denmark	43.7%	7.1%	7.8%	31.3%	10.1%	1
Hungary	38.4%	17.1%	0.3%	38.3%	5.9%	1
Malta	36.8%	21.6%	0.0%	41.6%	0.0%	1
Netherlands	47.1%	0.0%	7.7%	43.8%	1.4%	1
Poland	59.2%	0.0%	0.0%	35.5%	5.3%	1
Portugal	44.0%	4.2%	14.2%	37.1%	0.6%	1
Slovenia	52.2%	8.2%	8.2%	29.1%	2.3%	1
Spain	58.0%	9.6%	6.4%	26.0%	0.0%	1
Sweden	42.7%	6.9%	7.0%	24.3%	19.1%	1
Cyprus	91.0%	0.0%	6.9%	0.6%	1.5%	2
Finland	59.4%	5.9%	14.0%	14.3%	6.4%	2
Luxembourg	66.5%	18.0%	5.3%	9.5%	0.7%	2
Czech Rep.	35.7%	6.4%	1.9%	21.6%	34.4%	3
Estonia	45.0%	0.0%	1.1%	25.2%	28.8%	3
Latvia	39.1%	0.3%	0.1%	16.5%	44.0%	3
Lithuania	41.7%	0.6%	0.0%	19.0%	38.7%	3
Slovakia	44.4%	0.0%	0.0%	11.9%	43.7%	3
France	51.5%	19.6%	22.9%	6.1%	0.0%	4
Germany	43.5%	22.7%	29.1%	4.0%	0.6%	4
Italy	63.6%	14.4%	17.8%	0.0%	4.3%	4
Greece	51.2%	42.0%	6.0%	0.0%	0.8%	5
Ireland	40.5%	24.4%	3.5%	12.3%	19.3%	5
UK	24.3%	44.8%	4.1%	26.7%	0.1%	5

Data Source: European Competitive Telecoms Association (ECTA)

[20] I also ran an Agglomerative Hierarchical Clustering (AHC) analysis. This produced the same clusters except that Italy was placed in cluster 2.

6. Econometric Analysis of Drivers of Broadband Demand

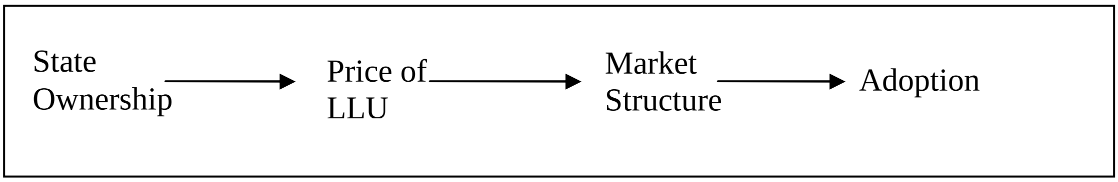
6.1 Hypotheses

In general terms, we would expect that the penetration rate of broadband would be driven by price and demand side variables, and so could be expressed as:

$$Broadband\,Adoption = f(\text{Price}, \text{other variables})$$

Price is likely to be affected by market structure, in that a more competitive market is likely to result in lower prices as suppliers compete aggressively for new customers. As we have seen in Section 5, the market structure is in turn affected by policy decisions. We can therefore postulate that a causal link exists between policy and demand as illustrated in Figure 3.

Figure 3: Causal Relationship between Policy and Adoption[21]



Retail price data for broadband access is extremely difficult to calculate. There are many retailers of broadband access in each country offering a wide variety of packages, in some cases bundled with other products such as TV and/or telephony. It is therefore not possible to include retail price in the following analysis.

To test this causal relationship, I suggest three interlinked hypotheses.

Hypothesis 1: In countries where the state retains any ownership in the incumbent operator, prices of unbundled local loops will tend to be higher. This is because the state has no incentive to lower the price of unbundled local loops

[21] It may be that a feedback loop exists between public policy and market structure, i.e. policy makers determine that the market is not delivering desired outcomes and so intervene to attempt to achieve these outcomes. Such a relationship is not explored in this paper.

to encourage market entry by competitors to its own, at least partially, incumbent operator.

Hypothesis 2: Higher prices of unbundled local loops tend to result in more concentrated markets. This is because entrants will be discouraged from market entry by the high price of local loops.

Hypothesis 3: Less concentrated markets stimulate broadband adoption. Further, both the current level of market concentration and the change in market concentration are expected to have strong effects on the level of broadband adoption. I expect that less concentrated, more competitive markets incentivise suppliers to sell broadband connections through both price and non-price activities.

6.2 Models

To test these hypotheses, I have developed three sets of models.

The first model simply compares the mean price of unbundled local loops in countries where the state retains any level of ownership in the incumbent fixed line operator with those where the state has divested all shares. Data is used for the 14 pre-2004 EU Member States as at 2006 Q3 to ensure consistency with the following models.

The second model examines the relationship between market concentration and the price of unbundled local loops. As noted in Section 2 of this paper, unbundled local loops form a market susceptible to *ex ante* regulation, known as Market 4. National regulators in all EU Member States have found incumbent operators to have SMP in Market 4 and have imposed some form of price control on the incumbent. The regulator therefore directly affects the price of unbundled loops and therefore the attractiveness of LLU as an input for market entrants. Higher prices of LLU raise barriers to entry and so reduce entry resulting in a higher level of market concentration.

To test this hypothesis I develop a pooled time-series cross-section model using data from 14 of the pre-2004 EU Member States over the period 2002 Q3 to 2006 Q3. Greece has been excluded from the sample due to data problems in the early part of the time series. This sample of countries allows for a longer time series as ECTA did not collect data for the New Member States until after they joined the EU in 2004.

The third model examines the relationship between broadband adoption and market concentration for the same sample of countries over the same time period. A Lagged Dependent Variable model has been developed to capture the dynamic nature of the market.

6.3 Variables Used

The variables in the models are described below.

BBPEN Broadband Penetration is the total number of broadband subscribers, as reported by ECTA, divided by the population of the country using annual population data. BBPEN is taken at the end of the fourth quarter of each year used in the model, which allows me to align penetration data with other variables. Broadband subscriber numbers are provided separately by business and residential customers. Alternative measures of broadband adoption would be as a proportion of households or as a proportion of all access lines. However, as the International Telecommunications Union (ITU) uses telephone lines per capita as the measure of tele-density, I have chosen to be consistent with this measure of adoption. It is also consistent with Bauer et al (2003).

HHI HHI measures platform concentration (as a proxy for competition) at the retail level. The market share of the five platforms described in Section 4 (incumbent, bitstream, LLU, cable and other) are used to calculate the HHI. Ideally data on the market share of each firm would be used to calculate the HHI, but such detailed data are not available.

PLLU	This variable measures the wholesale price of unbundled local loops (source: European Commission, 2004, 2006) which is normally set by regulation on a cost-oriented basis. The price is calculated by taking the weighted average of the price for fully and partially unbundled loops at the country level, using the proportion of each type of unbundled loop as the weight. Prices used in this paper are nominal.
SLLU	The percentage market share of LLU in the broadband market.
GDPCAP	On the expectation that wealthier countries will adopt broadband faster, I include GDP per capita as an explanatory variable.
LAUNCH	This measures the period in months since the launch of DSL by the incumbent operator. The variable has been included on the expectation that countries with longer experience of broadband will have a higher level of penetration as consumers become more aware of the product and its benefits to them. The period since the launch of DSL is an imperfect proxy for the launch of all broadband as in some countries cable broadband may have been available before DSL. However, data for the launch of DSL are available from the OECD and national regulators.
LAUNCHSQ	This variable is the square of LAUNCH. Squaring the period since launch captures the expectation that growth in subscribers will be non-linear, i.e. it is likely to flatten-off as the market becomes saturated.

Retail price is omitted from the model for a number of reasons. First, prices vary significantly by package with different upload and download speeds and some have a monthly limit on the volume of data which can be downloaded. However, the omission of retail price may be of less concern than would normally be expected for two reasons: first, the models include the wholesale price of LLU which could be expected to bear some relationship to the retail price; and second, the model includes HHI as an indicator of the competition between broadband access platforms. As the broadband market has become more mature, we would expect there to be a positive relationship between retail price and HHI: a less concentrated market will encourage firms to become more productively efficient and to pass those efficiency gains on to customers in the form of price reductions. We may therefore find an endogeneity problem if both price and HHI are included in the model (Bauer et al, 2003).

6.4 Econometric Specification and Estimation Results

6.4.1 State Ownership and Price of Unbundled Loops

Table 2 lists the 14 countries in the sample sorted into two groups: those where the state holds 0% of shares in the incumbent and those where the state holds at least one share. Within each sub-group the countries are sorted alphabetically. The price of LLU is the weighted average price of fully and partially unbundled loops for each country, taking the proportion of each type of loop as the weighting factor.

Table 2: State Ownership and LLU Prices

Country	State Share	Price LLU (€month)
Denmark	0	8.91
Spain	0	7.98
Ireland	0	15.91
Italy	0	8.02
Netherlands	0	5.97
UK	0	6.80
Austria	25.4	11.80
Belgium	50.1	8.42
Germany	31.3	11.72
Finland	13.7	12.98
France	32.5	8.25
Luxembourg	100	14.36
Portugal	6.9	10.80
Sweden	45.3	9.57

Based on this data the mean prices of LLU for each group are €8.90 and €11.0 per month respectively. Using a Mann-Witney Test of the difference between the means we find that the difference is significantly different from zero at 8.1% significance. With such small samples and a significance level worse than 5% it is not possible to draw the conclusion that LLU prices are higher where the state retains some ownership, but we can draw the tentative conclusion that the trend is in that direction.

6.4.2 LLU Prices and Market Structure

So, if the price of LLU tends to be higher where the state retains some level of ownership of the incumbent, does this go on to affect market structure? My second hypothesis, therefore, is that market concentration will be lower where prices of LLU are also lower. Ideally this would be tested using the price of LLU relative to other forms of broadband infrastructure. However, data on equivalent costs are not available and so I can only test this hypothesis using the price of LLU as a stand-alone item.

I have produced a time-series cross-section model using both level and log values for HHI and PLLU. The results are shown in Table 3. T-statistics are in parentheses below the coefficient. Fixed effects models are used in both cases.

Table 3: Level and Log Values for HHI and PLLU

Dependent Variable = HHI	Level Model	Log Model
PLLU	53.27 (5.11)	0.18 (7.51)
Adjusted R^2 (unweighted)	0.54	0.58
Durbin Watson	1.30	1.51

The models have good predictive qualities and no significant problems with autocorrelation. They suggest that the price of unbundled local loops has a significant though not particularly strong influence on market concentration in the expected direction. Given the relatively low market shares of LLU in most countries, a weak coefficient is not surprising.

Further analysis indicates a direct relationship between the price of LLU and the market share of LLU operators, suggesting that the relationship shown above is not random. Taking the market share of LLU as the dependent variable and the PLLU as the explanatory variable in a pooled time-series cross-section model yields the results shown in Table 4.

Table 4: Level and Log Values for SLLU and PLLU

Dependent Variable = SLLU	Level Model	Log Model
PLLU	-0.19 (-2.57)	-1.43 (-5.74)
Adjusted R^2	0.51	0.67
Durbin Watson	1.47	1.31

The level model shows the relationship between the price level of LLU and SLLU to be significant at 5%. The logged model shows a high level of significance and an elastic coefficient indicating that a 1% fall in LLU prices would see a 1.43% increase in the share of LLU. The model has good predictive qualities and minimal problems with autocorrelation.

6.4.3 Pooled Time-Series Cross-Section Models

Having found that the price of LLU affects both the overall market concentration and the share of LLU, I now go on to examine how market concentration affects adoption of broadband.

I expect that market structure will have an effect not just in the current period, but also in future periods. This is because, whilst I would expect market structure to feed through to pricing and marketing conduct in the current period, consumers' decisions to buy may be delayed, though the strongest effect would be in the current period. Likewise, the changing wealth of consumers, measured by GDP per capita, may have its strongest effect on buying decisions in the current period, but may also affect decisions in later periods.

One model form often used to test for such lagged behaviour is the geometric lag model, in which independent variables are lagged for an infinite number of periods. This is expressed in its most general form as:

$$y_t = \alpha_0 + \beta_0 (X_t + \lambda X_{t-1} + \lambda^2 X_{t-2} + \cdots) + u_t$$

Where $0 \leq \lambda \leq 1$

In practice calculating a geometric lag model is an impossible task as the model has an infinite number of terms and parameters. However, the model can be transformed into a Lagged Dependent Variable (LDV) model using the Koyck transformation:

1) $Y_t = a_0 + \beta_0(X_t + \lambda X_{t-1} + \lambda^2 X_{t-2} + ...) + u_t$

lag one period 2): $Y_{t-1} = a_0 + \beta_0(X_{t-1} + \lambda X_{t-2} + \lambda^2 X_{t-3} + ...) + u_{t-1}$

multiply by λ 3): $\lambda Y_{t-1} = \lambda a_0 + \beta_0(\lambda X_{t-1}+\lambda^2 X_{t-2} + \lambda^3 X_{t-3} + ...) + \lambda u_{t-1}$

subtract (3) from (1) to get 4): $Y_t - \lambda Y_{t-1} = (1-\lambda)a_0 + \beta_0 X_t + u_t - \lambda u_{t-1}$

The LDV model has the advantage of being practical and of using few degrees of freedom for the estimation. The model also calculates both the long- and the short-term elasticities for each of the independent variables. The LDV model used in this paper is:

$$Log(BBPEN) = \alpha + \beta LOG(BBPEN - 1) + \chi LOG(HHI) + \delta LOG(GDPCAP) + \phi LAUNCH + \varphi LAUNCHSQ$$

and yields the results shown in Table 5.

Table 5: LDV Model Results, 2003–2006

Dependent Variable: LOG (BBPEN?)				
Method: GLS (Cross-Section Weights)				
Sample: 2003–2006				
Included observations: 4				
Number of cross-sections used: 14				
Total panel (balanced) observations: 56				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.630537	1.073171	-0.587546	0.5595
LOG(BBPEN?(-1))	0.655059	0.024750	26.46673	0.0000
LOG(HHI?)	-0.191669	0.062895	-3.047429	0.0037
LOG(GDPCAP?)	0.291868	0.084370	3.459393	0.0011
LAUNCH?	0.013579	0.006634	2.046936	0.0459
LAUNCHSQ?	-0.000119	5.75E-05	-2.063480	0.0443
Unweighted Statistics				
R-squared	0.965772	Mean dependent var		2.334218
Adjusted R-squared	0.962349	S.D. dependent var		0.723938
S.E. of regression	0.140472	Sum squared resid		0.986621
Durbin-Watson stat	1.851680			

I have tested the robustness of this model by removing one time period for all countries and producing the same model for the period 2003–2005. The results are shown in Table 6.

Table 6: LDV Model Results, 2003–2005

Dependent Variable: LOG (BBPEN?)				
Method: GLS (Cross-Section Weights)				
Sample: 2003–2005				
Included observations: 3				
Number of cross-sections used: 14				
Total panel (balanced) observations: 42				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.997509	1.422886	-0.701046	0.4878
LOG(BBPEN?(-1))	0.648591	0.026116	24.83475	0.0000
LOG(HHI?)	-0.204448	0.071776	-2.848406	0.0072
LOG(GDPCAP?)	0.306692	0.115610	2.652808	0.0118
LAUNCH?	0.028288	0.011126	2.542411	0.0155
LAUNCHSQ?	-0.000279	0.000113	-2.474365	0.0182
Unweighted Statistics				
R-squared	0.958407	Mean dependent var		2.131162
Adjusted R-squared	0.952631	S.D. dependent var		0.714758
S.E. of regression	0.155564	Sum squared resid		0.871204
Durbin-Watson stat	2.059908			

The coefficients and t-Statistics for each of the variables are virtually identical suggesting that the model is robust and not affected by the period covered.

In a Lagged Dependent Variable model we do not know whether the error term u_t is serially correlated or not. If this is the case, it is also correlated with $y_{t-1.}$ The Durbin-Watson statistic, which is used to test for auto-correlation in time-series/cross-sectional models without a lagged dependent variable is not applicable in this case and has to be replaced with the Durbin-h test:

$$Durbin\, h = r(n/1 - n \times \mathrm{var}(b))^{1/2}$$

Where r = 1 – Durbin Watson/2, n is sample size, var(b) is the variance of the coefficient on the lagged dependent variable i.e. its standard error squared.
With Durbin-h we set up a null and alternative hypothesis, as follows:

Ho: no 1^{st} order autocorrelation
Ha: 1^{st} order autocorrelation

We test by comparing the Durbin-h against the critical value for the normal distribution for a one tailed test: ±1.645 at 95% confidence. If the Durbin-h exceeds the critical value we reject the null-hypothesis. In the case of the two models above the Durbin-h are 0.571 and -0.197. In both models therefore we cannot reject the null hypothesis of no first order correlation.

The models therefore are robust (unaffected by the removal of one time period), do not suffer from first order correlation, and have strong predictive qualities with all coefficients significant at least 5%.

An LDV model can be used to calculate both short-term and long-term elasticities. In a double log model, such as those produced above, the coefficient on each of the independent variables can be interpreted as an elasticity.

The short-term elasticity is the coefficient of the independent variable of interest, thus the short-term elasticity for HHI is -0.19, suggesting that a 1% decrease in HHI will lead to a 0.19% increase in broadband penetration (at 1% significance).

The long-term elasticity is calculated as $\beta/(1-LDV)$, where β is the coefficient of the independent variable of interest, and LDV is coefficient of the lagged dependent variable. The long-term elasticity of HHI is therefore:

$$-0.19/(1-0.66) = -0.56$$

Thus in the long-term, a 1% decrease in HHI leads to 0.56% increase in broadband penetration.

The inclusion of both LAUNCH and LAUNCHSQ tests to determine whether there is a non-linear “experience effect” of the availability of broadband: i.e. an S curve relationship such that growth in broadband subscribers is initially slow, then accelerates, before eventually tailing off. A positive coefficient on LAUNCH and a negative coefficient on LAUNCHSQ suggest that broadband is in the rapid growth phase and has not yet reached the point at which growth tails off. I have tested whether a non-linear relationship is likely by removing LAUNCHSQ from the model. This had the effect of lowering the R^2 and the coefficient on LAUNCH becoming insignificant, indicating that the model benefits from the non-linear LAUNCHSQ variable.[22]

6.5 Discussion of Results

I now discuss the results of these models in relation to my three hypotheses.

Hypothesis 1: I find that prices of LLU tend to be higher where the state retains some level of shareholding in the incumbent operator. There is no direct correlation between the percentage of shares held and price. The model does not suggest why it should be the case that state ownership leads to higher LLU prices, but I would expect this to be because the state wishes to protect its interest from competition which may lower the value of its shares.

Hypothesis 2: I find that lower LLU prices both reduce market concentration overall and increase the market share of LLU. This is found to be the case without reference to prices for other forms of wholesale access. This can only be taken as a tentative result as to establish a more robust result would require information on the relative price of alternatives. Nevertheless, we can conclude from this that NRAs which have used their powers to force down prices of LLU have been rewarded with the expected results: a less concentrated broadband market. Changes in LLU prices have a greater effect on the share of LLU than the actual level of price.

Hypothesis 3: The competitive effects on broadband take-up. Market structure is found to have a significant effect on the take-up of broadband across the sample countries, with the effect taking time to be fully realised.

These findings support Distaso et al (2004) but go further in showing that it is not just competition between DSL and cable that promotes take-up, but competition across all broadband access technologies. My model demonstrates

[22] LAUNCH and LAUNCHSQ are constrained to be the same for all countries. Removing this constraint shows that countries are at different stages of market development.

the importance of the dynamic nature of competition in driving broadband adoption.

The wealth variable (GDP per capita) is also found to have a positive effect on broadband penetration: richer countries tend to have higher adoption rates.

The causal relationship illustrated in Figure 4 holds: public policy with regard to state ownership leads to lower LLU prices which reduce market concentration, which in turn increases broadband adoption.

Therefore regulators which use their powers to ensure that the price of LLU is set at cost, and which do not allow incumbent operators to exploit their monopoly over copper access lines, will see greater adoption of broadband with attendant benefits for both consumers and the country.

7. Conclusions and Implications for Policy Makers

I have observed that there are differences in the way in which the NRF has been implemented by EU Member States and that there are differences in broadband market structure. However, if we assume that incumbent operators would not willingly provide LLU without regulatory prescription, then regulatory policy has at least some effect on the extent of LLU in each market. This is observable in France, Sweden and the UK, which have recently placed greater emphasis on LLU and have seen growth in the number of unbundled lines.

The cable sector in each country seems to be almost an accident of history, rather than affected by a deliberate policy of encouraging infrastructure-based competition from alternative local access providers. There are strange anomalies in the cable sector, such as Germany where ubiquitous cable TV access has not resulted in cable being a significant player in the broadband access market.

The price of unbundled local loops, which is directly affected through price control regulation in Market 4, is found to have a strong effect on the share of LLU in the wholesale broadband market (Market 5). Lower prices clearly stimulate either or both of greater market entry and expansion by existing LLUOs.

The models show that competition between differentiated broadband access technologies at the wholesale level (Market 5) has a strong effect on consumers' take-up of broadband. As the market structure has become less concentrated, which I take as a proxy for more competition, so broadband penetration has increased.

Any action by the regulator to reduce market concentration will, *ceteris parabis*, increase demand for broadband. The easiest policy variable for the NRA to affect is the price of LLU. Whilst lower prices for LLU would clearly have a beneficial effect on the take-up of broadband, it would be unreasonable, and indeed economically inefficient, for NRAs to expect SMP operators in Market 4 to sell LLU below cost. It may also not be possible as it has been politically agreed that the incumbent (SMP operator) should be able to recover its efficiently incurred costs through the price of LLU (de Bijl and Peitz, 2002).

There are several ways in which the models included in this paper could be developed. First, by having data on the costs of alternative entry methods (own access infrastructure and bitstream) a better demand for LLU could be created to measure the effect of the relative price of LLU on market entry. Second, firm level market shares in wholesale and retail broadband markets would help measure the true state of market concentration as in all countries we can expect more than one firm to be active in each alternative technology. Finally, consumer prices would help measure the price elasticity of demand for broadband and determine whether the endogenteity problem expected by Bauer et al (2003) does indeed exist.

The European Commission's frustration with the implementation of the NRF is justified by the evidence and analysis presented in this paper. The different degrees of enthusiasm with which Member States have used LLU to introduce competition into broadband markets appear to have had an effect on market structure. The concentration of these markets is an important factor in driving the demand for broadband and therefore meeting the i2010 and Lisbon policy goals. Whether this means that the European Commission should have greater powers to impose its wishes on Members States, however, is a political matter beyond the scope of this paper.

References

Arquette T.J. (2002) *Social Discourse, Scientific Method and the Digital Divide* Chicago, Northwestern University

Bauer, J.M., Kim, J.H. and Wildman, S.S. (2003) *Broadband uptake in OECD countries: Policy lessons and unexplained patterns* Paper presented at International Telecommunications Society, European Regional Conference, August 2003

Blowers, A and Cadman, R., (2003) *Stimulating Innovation in Electronic Communications Markets: A Manifesto for Ofcom* Mimeo

Broadband Wales Observatory (2005A) *Sweden – Broadband Market* available at http://www.broadbandwalesobservatory.org.uk/

Broadband Wales Observatory (2005B) *France –An Overview of the Broadband Market* available at http://www.broadbandwalesobservatory.org.uk/

Cava-Ferreruela, Immaculada and Alabau-Muñoz, Antonio (2006) *Broadband policy assessment: A cross-national empirical analysis* Telecommunications Policy 30, (2006) 445-463

CPB (2005) *Regulation of telecommunication and deployment of backbone* CPB (Netherlands Bureau for Economic Policy Analysis) Memorandum No. 131 December 2005

De Bijl, Paul and Peitz, Martin (2002) *Regulation and Entry into Telecommunications Markets* Cambridge University Press

Distaso, W. Lupi, P and Manenti, F.M. (2004) *Platform Competition and Broadband Adoption in Europe: Theory and Empirical Evidence from the European Union* Information Economics and Policy 18 (2006) 87–106

Dot Econ and Criterion Economics (2003) *Competition in Broadband and its Implications for Regulatory Policy* Report for the Brussels Round Table

DTI (2004) *UK National Broadband Strategy 2004*

ECTA, Jones Day, SPC Network (2005) *European Regulatory Scorecard*

ECTA, Jones Day, SPC Network (2006) *European Regulatory Scorecard*

European Commission (2003) *COMMISSION RECOMMENDATION On Relevant Product and Service Markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communication networks and services*

European Commission (2004) *European Electronic Communications Regulation and Markets 2004 (9th Report)*

European Commission (2005) *i2010 – A European Information Society for growth and employment*

European Commission (2006) *European Electronic Communications Regulation and Markets 2005 (11th Report)*

European Commission (2007) *COMMISSION RECOMMENDATION On Relevant Product and Service Markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communication networks and services (Second Edition)* C(2007) 5406 rev 1

Hazlett, T.W., (2006) *Germany's Cable Problem* Wall Street Journal August 30th 2006

Howell, B (2002) *Broadband Uptake and Infrastructure Regulation: Evidence from the OECD Countries* New Zealand Institute for the Study of Competition and Regulation (ISCR) Working Paper BH02/01

Krafft, Jackie (2006) *Emergence and Growth of Broadband in the French Infocommunications System of Innovation* in Fransman, M 'Global Broadband Battles: Why the US and Europe lag while Asia leads' (2006) Stanford University Press

OECD (2002) *Broadband Infrastructure Deployment: The Role of Government Assistance*

OECD (2003) *Broadband Driving Growth: Policy Responses*

OECD (2005) *New Perspectives on ICT Skills and Employment*

OECD (2006) *Telecommunication Regulatory Institutional Structures and Responsibilities*

OPTA (2006) *Annual Report and Market Monitor 2005* www.opta.nl published 5/12/2006

Office of the Telecoms Adjudicator (2006) *Update for November 2006* www.offta.org.uk

Reding, V., (2007) *Towards a true internal market for Europe's telecom industry and consumers: the regulatory challenges ahead* Speech to 20th Plenary Meeting of the European Regulators Group, Brussels, 15th February 2007.

Schulz, W., Jűrgens, U., Held, T., Dreyer, S., (2002) *Regulation of Broadcasting and Internet Services in Germany: a brief overview* Hans Bredow Institute Working Papers No. 13

Vanberg, Margrit A., (2002) *Competition in the German Broadband Access Market* Centre for European Economic Research Discussion Paper No. 02-80

WIK (2006) "Kabelinternet in Deutschland" Report on behalf of Deutscher Kabelverband