Remedies for Non-Price Discrimination:
Their Application in the UK Broadband Market and their Effect on Investment Decisions

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ABSTRACT

In 2004, Ofcom launched a strategic review of the telecommunications market. This established that the expectation of non-price discrimination by the incumbent operator, BT, against its smaller rivals was a significant concern holding back investment in market entry via local loop unbundling (LLU). To address this problem, Ofcom and BT agreed a set of Undertakings in lieu of a reference to the Competition Commission. BT agreed to a new form of non-discrimination remedy referred to as Equivalence of Input (EoI) and to a set of organisational changes known as functional separation. Under EoI, BT's retail division had to use the same inputs under the same terms and conditions as its rivals. Functional separation referred to the creation of a separate access services division that would supply services in markets where BT was dominant.

This thesis discusses the economic principles of network industries and why discrimination can be a particular problem. It makes three specific contributions to knowledge of the subject. First, a historical record of the actions and issues that led to the Undertakings. Secondly, a breakeven analysis to determine how effective the Undertakings, and other regulations imposed by Ofcom, were at correcting the problem of non-price discrimination. The breakeven analysis establishes the location of "marginal exchange" before and after the regulatory changes. Finally, an assessment of the longer-term consequences by employing a discrete choice model to determine whether the presence of entrants using LLU or Virgin Media had a stronger effect on where BT installed fibre.

The thesis concludes that the Undertakings did affect the location of the marginal exchange by up to 950 exchanges covering 31% of customer premises. LLU price cuts imposed by Ofcom moved the marginal exchange by a further 796 exchanges: 11% of premises. The thesis also finds that up till the end of 2012, the presence of LLU operators had a stronger influence on the location of fibred exchanges than Virgin Media.

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1   Synopsis

Broadband access to the Internet has been at the centre of European and national telecommunications policy for nearly fifteen years. Policy makers regard widespread, indeed ubiquitous, access to the Internet as essential to economic competitiveness and social inclusion. However, the economics of building fixed telecommunications networks means that the access network, the "last mile" connection between the customer premises and the telephone exchange, has the characteristics of a natural monopoly. Throughout Europe, this bottleneck facility, known as the local loop, is owned by a vertically integrated incumbent operator. To ensure a competitive retail broadband market the incumbents' rivals need access to the local loop.

European regulation of the sector has required the incumbent to unbundle the local loop and make it available to competitors since 2000. However, by mid-2005 BT's competitors in the UK had taken advantage of local loop unbundling in just 321 of the 5,581 exchanges in the UK and just 85,000 broadband lines were provided using Local Loop Unbundling (LLU) out of a total of eight million broadband subscriptions. By comparison, in France at the same time over two million broadband connections were provided using LLU.

To correct this situation, Ofcom, the sector regulator, took three specific actions in 2005. First it agreed a set of voluntary Undertakings (Ofcom, 2005) with BT under which BT agreed to a set of behavioural and organisational changes designed to deter, and remove the incentives for, non-price discrimination by BT against its rivals[1]. Secondly, Ofcom imposed a price control on BT that cut the price it could charge to entrants for unbundled local loops by 85%. Thirdly, it created an industry body, the Office of Telecoms Adjudication (OTA), whose job was to make the process for renting unbundled local loops "fit for purpose".

Ten years after signing the Undertakings, Ofcom's actions continue to be the subject of intense argument amongst academics, industry participants and policy makers. The organisational changes within BT, known as 'functional separation', have been especially debated. Often, however, functional separation has not been placed in the wider context of Ofcom's three actions and has been confused with structural, or ownership, separation. Further, much of the debate has not examined the short- and long-run effects of these actions on decisions by entrants about where to enter the market and their technology choices.

This thesis seeks to address the gaps in the debate by:

1.   Examining the actions taken by Ofcom holistically, i.e. not exploring just one action, but all three and the relationship between them (Chapter 4).
2.   Measuring the short-term, static efficiency effects on the UK broadband market structure at the wholesale level, and in particular the entry choices

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[1] It will be shown later that competitors regarded non-price discrimination as a major roadblock to investment.
[2] A position equivalent to dominance in the relevant market.

made by BT's rivals. It also seeks to separate the effects of the Undertakings from those of the price cut (Chapter 5).

3. Measuring the long-term, dynamic efficiency effects by exploring how BT responded to competitors' actions through its choice of where to upgrade the existing copper access network to fibre, allowing much higher speed of access to the Internet (Chapter 6).

The thesis is organised as follows:

Chapters 2 and 3 set the context. Chapter 2 describes the economics of dominance, the abuse of dominance in general and the remedies available to competition authorities under EU and UK law. Chapter 3 introduces the structure of the electronic communications sector and discusses the economic principles in the context of the sector. In particular, the chapter examines how the local access network (the "local loop") is an economic bottleneck with natural monopoly characteristics. Downstream of the local loop, in retailing activities, competition is economically feasible provided that entrants can access the local loop on fair and reasonable terms. However, in the absence of effective regulation the incumbent has no incentive to provide such access. In fact, the incumbent has the incentive to foreclose competition by denying access with the intent of extending its monopoly power from the upstream to the downstream segment of the market (Rey and Tirole, 2007).

Chapter 4 presents a historical record of the actions taken by Ofcom to address the perceived level of foreclosure affected by BT against its rivals. In 2004, Ofcom launched its Strategic Review of Telecommunications to examine the competitiveness of the telecoms market (Ofcom, 2004, 2004B, 2005). Many respondents argued that perceived discrimination by BT was the key issue preventing further investment in LLU and therefore a more competitive broadband market. Ofcom agreed with these submissions and stated in the second phase consultation document that BT's rivals had "experienced twenty years of:

- slow product development;

- inferior quality wholesale products;

- poor transactional processes; and

- a general lack of transparency." (Ofcom, 2004B, para. 1.19)

Ofcom determined that the "no undue discrimination" obligation that had been imposed on BT as a result of its Significant Market Power (SMP)[2] had been insufficient to deter discrimination. This was because the obligation only required "equivalent conditions in equivalent circumstances" and Oftel, Ofcom's predecessor, allowed BT to design wholesale products used by other communications providers that were different to products used by BT's own retail divisions. Any underlying cost differences between these products were

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[2] A position equivalent to dominance in the relevant market.

considered by Oftel to be justifiable reasons for different treatment (Oftel, 2002). Ofcom's response to the problem of discrimination was to agree with BT a set of Undertakings in lieu of a reference to the Competition Commission that introduced two major changes to BT's behaviour and organisation:

1) Equivalence of Input (EoI), by which BT had to use the same upstream inputs as its rivals under the same terms and conditions; and
2) "Functional Separation": a reorganisation of BT so that natural monopoly assets were provided by a separate Access Services division to BT's own retail divisions and its rivals. The objective of functional separation was to remove the incentive for BT to discriminate and to make any discriminatory behaviour more visible to Ofcom.

At the same time, Ofcom also reduced, by 85%, the price that BT was allowed to charge for unbundled local loops from one very much above the EU average to at or below that average, dependent on the type of unbundled loop.

This part of the thesis also critically examines the debate about Ofcom's actions and presents brief case studies of similar actions taken by regulators in other countries and in other sectors.

Chapters 5 and 6 explore the effects of the changes introduced by Ofcom in 2005. Chapter 5 sets up two metrics by which the effectiveness of these changes can be measured: the ratio of unbundled local loops to all forms of competitive copper access (LLU:CCA), and the location of the marginal exchange, i.e. the exchange at which an entrant is indifferent between investing in LLU and using a form of reselling BT's broadband product. The thesis proposes that the greater the LLU:CCA ratio and fewer the total number of premises in the marginal exchange, the more successful Ofcom has been in reducing discrimination. The thesis then analyses the take up of LLU and locates the marginal exchange to determine the relative effects of the Undertakings and the price cut on the broadband market structure. The chapter concludes that it is not possible to untangle the effects of the Undertakings from the price cut when measuring the LLU:CCA ratio as a measure of effectiveness. However, it also concludes that the Undertakings moved the marginal exchange by between 282 and 951 exchanges, increasing the number of premises that could be served by LLU by between six and 31 percentage points. The price reduction moved the marginal exchange by 796 exchanges and increased the number of premises by 11 percentage points.

Chapter 6 explores BT's investment in Next Generation Access (NGA) and examines the strength of the effect of LLU-based competitors on its choice of where to invest in fibre access. It finds that BT was three to ten times more likely to invest in fibre broadband access in exchange areas where LLU operators were present than where the cable company Virgin Media was present.

Overall, therefore, the thesis concludes that the impact of EoI and functional separation was to reduce entrants' expectations that BT would discriminate

against them and that they therefore encouraged increased investment in LLU. The increased competition from LLU operators, and the change in the locus of competition from broadband access speeds to TV content, encouraged BT to invest in NGA to compete with LLU operators rather than cable.

The thesis does not seek to address the effects of Ofcom's regulatory changes at the consumer level. It does not, therefore, examine whether they led to an increase in the rate of take up of broadband, the prices consumers paid or the quality of services they received. These would all be fruitful areas for further research. However, this thesis is concerned with choices made by entrants.

2   Economic Principles of Market Power and Non-Price Discrimination

The application of regulation and competition law is based on the concept of market power in a relevant market, and the abuse of that position. In sector specific regulation, firms that are found to have market power are regulated regardless of whether they have abused their dominant position or not. Under competition law, however, remedies can only be imposed if an abuse has been established. This chapter explores the basic economic principles of market power and the remedies available under EU and UK law.

2.1   Market Power

Markets, whether for telecommunications services or any other economic good, exist on a continuum ranging from perfect competition at one end to a pure monopoly at the other[3]. Towards the monopoly end is the concept of dominance, which is a crucial concept in the economics of competition law and economic regulation (Motta, 2004). Economically, dominance refers to the ability of a firm to raise prices substantially above the competitive level, profitably and is defined in European case law as:

> *"…a position of economic strength enjoyed by an undertaking, which enables it to prevent effective competition being maintained on the relevant market by affording it <u>the power to behave to an appreciable extent independently of its competitors, its customers and ultimately of the consumers</u>. Such a position does not preclude some competition, which it does where there is monopoly or quasi-monopoly, but enables the undertaking, which profits by it, if not to determine, at least to have an appreciable influence on the conditions under which that competition will develop, and in any case to act largely in disregard of it so long as such conduct does not operate to its detriment." (emphasis added)* [4]

Closely related concepts to dominance are "market power" and significant market power". These are sometimes used as interchangeably with dominance and sometimes take a slightly different meaning. The fine distinctions between "dominance", "market power" and "significant market power" are not the subject of this thesis and so will be used interchangeably.

The definition of dominance used in the USA is rather more economic, in that it specifically refers to a firm's ability to price above the competitive level. However is also more restrictive as it is concerned only with price and profit but not other aspects of behaviour that can be captured by the European definition, for example reduction in quality. The US defines market power as:

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[3] More accurately perfect competition and pure monopoly are models of competition and very few actual markets exist at either end of the spectrum.

[4] Decision of the Court of First Instance and the European Court of Justice. Case 85/76 Hoffmann-LaRoche & Co AG v. Commission [1979] ECR 461 ("Hoffmann-LaRoche"), 34-5, 118n27, 499n122.

> *"The ability to price substantially above the competitive level and to persist in doing so for a significant period without erosion [of profit] by new entry or expansion."*[5]

The starting point for analysing market power is normally the share of the firm in the relevant market. Intuitively, a firm with a larger market share is likely to be more powerful within the market. At the extreme, a pure monopoly with 100% market share would be expected to have the highest possible market power, although even here its power could be reduced if the market is "contestable"[6]. However, a firm can have market power when it is not a monopoly and so competition authorities set thresholds below 100% at which a firm may be presumed to be dominant.

In the UK, the former Office of Fair Trading[7] (OFT) was very specific about the thresholds that it would use to measure dominance: a firm with a share above 50% may be presumed to be dominant, whilst a firm with a share below 40% would be presumed not to be dominant (OFT, 2004, para. 2.12). The presumption of dominance my be rebutted, and indeed there have been cases, in the UK and Europe, where a firm with a market share above 50% has been found not be dominant due to other mitigating factors, such as countervailing buyer power, discussed below.

However, all competition authorities recognise that market shares alone are not sufficient to determine whether a firm has market power or not and that other factors need to be taken into account. Two such factors are ease of entry and of expansion, and countervailing buyer power.

Ease of entry and expansion refers to the ability of existing or potential rivals to enter the market or increase their own capacity in response to a price rise above the competitive level by a potentially dominant firm. If barriers to entry and expansion are low, then a potentially dominant firm may find it is not possible to price above the competitive level for a significant period without erosion of profit.

Countervailing buyer power refers to the ability of buyers credibly to threaten to move their business to a rival or to bring production of the good in-house to such an extent that the potentially dominant firm's behaviour would be constrained. It would therefore prevent the firm from behaving independently of competitors, customers or consumers, or from pricing above the competitive level without the erosion of profit. Countervailing buyer power was instrumental in the Enso/Stora case, allowing a merger that created a firm with a market share of between 50 – 70% to proceed because the largest buyer, Tetrapak, bought around 60-80% of market output and could constrain the pricing behaviour of the new merged entity (Motta, 2004).

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[5] United States v. E. I. Du Pont de Nemours & Co., 351 U.S. 377, 391 (1956); United States v. Grinnell Corp., 384 U.S. 563, 571 (1966).

[6] A market is said to be contestable if there are no barriers to entry or exit. In theory, a monopolist's market power could be reduced if it could not exploit that power for fear of entry by rivals.

[7] Now merged with the Competition Commission to form Competition and Markets Authority (CMA).

Countervailing buyer power has been regarded as a phenomenon of industrial markets. However, with the emergence of social media, consumer groups have been able to organise themselves to exert power over suppliers. For example, when a mobile operator with a high market share in Greece attempted to raise prices for existing consumers, a campaign was launched on Facebook to force the operator to reduce prices with the threat that the entire Facebook group would leave to a competitor's network. The mobile operator responded by reducing prices because it took the threat seriously[8].

Market power may not only be applied in the market in which the firm is dominant, but may also be exercised in a closely related market: a concept referred to a "leveraged dominance", which is very similar to foreclosure. Here a firm that is dominant in one market restricts or denies its rivals access to an essential good that the dominant firm produces or controls and that the rival needs so that it can compete in the closely related market. The dominant firm thereby leverages its dominance into the closely related market.

Motta (2004, p. 483) explains the concept by way of a simple example. Suppose that a firm is a monopolist in Market A but faces competition in Market B where B is a complementary product to A. The firm could deny compatibility between A and competing versions of B and thereby leverage its monopoly position in Market A into Market B. Such leveraged dominance was at the heart of the European Microsoft case in which Microsoft denied interoperability between Windows PCs and non-Microsoft workgroup servers, as described in Kühn and Reenen (2009).

In competition law, the possession of market power is not *per se* illegal, only the abuse of that position by either exploiting consumers or anti-competitively harming competitors through practices such as exclusion or discrimination. Whether a dominant firm would want to behave in such a manner has been the subject of some debate over the years and is discussed below.

2.2   Why would a firm behave anti-competitively?

> *"If an economist finds something – a business practice of one sort or another – that he does not understand, he looks for a monopoly explanation. And as in this field we are very ignorant, the number of un-understandable practices tends to be very large, and the reliance on monopoly explanation, frequent."* (Coase, 1972, p.67)

In other words, just because we do not understand a firm's behaviour does not mean that the firm is behaving anti-competitively.

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[8] This example is taken from a complaint made before the Greek telecoms regulator, the EETT, in which the author was involved as advisor to one of the parties.

A simplistic, though not necessarily incorrect, assumption is that all firms are profit maximising and a firm is best able to achieve this by monopolising a market and restricting output, as explained in Figure 1 and accompanying text.

Figure 1: Profit Maximisation of a Monopolist
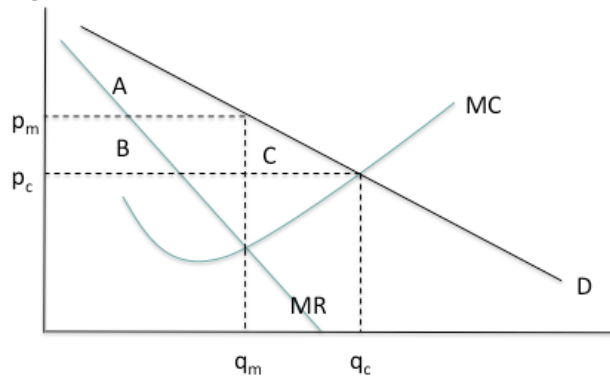
In a perfectly competitive market, producers would be expected to set price (p_c) where the marginal cost (MC) intersects the demand curve resulting in quantity q_c being supplied to the market. The resultant consumer welfare would consist of the sum of areas A, B and C. A profit maximising monopolist, however, would reduce the quantity produced to where the MC curve intersects with the marginal revenue (MR) curve, i.e. at q_m, resulting in the price being raised to p_m. As a result, consumer welfare is reduced to area A whilst the monopolist's profits are increased by B. Area C is the deadweight loss of monopoly.

However, few firms are genuine monopolies, and those that are tend to be constrained by regulation to prevent profit maximising behaviour. A dominant firm facing a competitive fringe can maximise profits through a variety of strategies dependent on the market conditions and behaviour of the competitive fringe. Two means by which a dominant firm can maximise profits are briefly discussed below.

First, the classic Bertrand model of duopoly, in which firms produce homogeneous products, compete on price and all consumers buy from the firm with the lower price, suggests that each firm would sell at a price equal to its marginal costs and therefore the duopoly price is the same as the competitive price. This happens because, in the Bertrand model, firms set their prices once and simultaneously and so the firm with the lower price wins all the business and the firm with the higher price wins none. Firms therefore set prices equal to marginal costs and, if the firms had the same marginal costs, then their prices would also be the same and neither would earn positive profits. A duopoly would, therefore, produce the same results as perfect competition. If the two firms have different marginal costs, the firm with the higher costs will exit the market.

It is generally recognised that such behaviour does not reflect what happens in reality as perfectly competitive duopolies are rarely observed in practice, and so the outcome from the Bertrand model is known as the *Bertrand Paradox*.

One solution to the Bertrand paradox is that at least one of the firms faces capacity constraints and can only serve part of the market. If its capacity is less than the total demand then a residual demand remains for the other firm. Suppose that the capacity constrained firm were the smaller rival to the dominant firm. The dominant firm could set a price for the residual demand above the price of the rival, and above its own marginal costs, as the rival could not respond, at least in the short run, by expanding capacity and increasing sales.

Secondly, in some markets (including telecoms) consumers face switching costs. These are the costs that a consumer incurs as a result of changing suppliers, brands or products and may be monetary, psychological or time-based switching costs. Consumers considering a switch from a large incumbent to a smaller rival are likely to do so if, and only if, the additional utility and/or lower price of the rival exceeds their switching costs (de Bijl and Peitz, 2002). Thus the dominant firm can afford to set a higher price than the smaller rival up to the level of consumers' switching costs, i.e. where:

$$P_d = P_r + z$$

Where P_d is the price of the dominant firm, P_r is the price of the rival and z represents switching costs. If P_d is greater than its marginal costs then the dominant firm is able to earn positive profits.

In all these examples, the profits of the dominant firm are likely to be less than total industry profits and so it could increase its profits by monopolising the market, potentially through anti-competitive action. However, whether a dominant firm would *always* behave anti-competitively has been the subject of considerable debate throughout the 20th and 21st centuries. There is not scope here to review all the arguments concerning this but, before considering how a firm can behave anti-competitively, the principal arguments for and against such an assumption are set out.

The Chicago School of antitrust economists, which was in the orthodoxy throughout much of the later 20th century, in the US at least, believes that markets tend toward efficiency and are self-correcting. Therefore, market imperfections, such as dominance or monopoly, are normally transitory and will be corrected by entry or expansion by rivals who will reduce the power of the dominant firm (Jacobs, 1995). Firms would not individually exploit a dominant position as to do so would invite retaliation by rivals and so competition policy should not concern itself with unilateral actions. Indeed, Chicagoans would argue that competition authorities should be careful not mistakenly to proscribe behaviour that promotes consumer welfare (Jacobs, 1995).

Posner gives several examples of Chicago School thinking, such as the extract below concerning predatory pricing.

> *"Selling below cost in order to drive out a competitor is unprofitable even in the long run, except in the unlikely case in which the intended victim*

lacks equal access to capital to finance a price war. The predator loses money during the period of predation and, if he tries to recoup it later by raising his price, new entrants will be attracted, the price will be bid down to the competitive level, and the attempt at recoupment will fail. Most alleged instances of below-cost pricing must, therefore, be attributable to factors other than a desire to eliminate competition." (Posner, 1979, p.927)

Much of Microsoft's defence against leveraged dominance rested on the Chicagoan view than a monopolist in one market would never have the incentive to leverage that dominance into anther market, due to the "one monopoly profit theory" (Kühn and Reenen, 2009). This theory suggests that where an upstream monopolist sells to a competitive downstream market, the upstream monopolist is able to extract all the profit from the market. It could not earn any higher profit from excluding rivals in related markets[9]. Chicagoans also use this theory to defend vertical acquisitions by a monopolist.

More recently, a post-Chicago school of thinking has emerged that is, according to its advocates, "both more complex and more ambiguous than the Chicago School model" (Hovenkamp, 1985, p.225). Both schools accept that competition policy should concern itself with efficiency and agree that a neoclassical, equilibrium-based research tradition is the appropriate starting point for analysis. However, post-Chicagoans are less optimistic about the self-correcting powers of the market and believe that market failures may be non-transitory.

One reason why failures may be non-transitory is the presence of high barriers to entry: "economic or technical factors which prevent or make it difficult for firms to enter a market and compete with existing suppliers"[10]. Barriers to entry include: sizeable initial capital investment that may be a sunk (non-recoverable) cost; regulatory factors, such as licences; and switching costs that deter consumers from changing suppliers from the incumbent firm.

In the absence of barriers to entry, consumers would quickly punish any incumbent firm that sought to behave anti-competitively, for example by raising prices above marginal costs, by switching to new entrants. The self-correcting market process would therefore deter such anti-competitive behaviour and market failures would be transitory. However, if an entrant faces significant barriers to entry then it is likely to be less willing to enter, as it would be less certain that it could do so profitably. It may consider that its capital would be better deployed in a market where it does not face an entrenched incumbent.

Taking the example of switching costs. Suppose that consumers face high costs to switch from the incumbent to an entrant. The entrant must entice consumers to move by offering lower prices than the incumbent to reward the consumer for her risk in moving supplier. If the discount the entrant must offer reduces its price

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[9] See Motta, 2004, p. 374, for a formal description of the one monopoly profit theory.
[10] 'Penguin Dictionary of Economics' 6th Edition, 1998.

below some relevant measure of cost, then the rival is unlikely to enter, leaving the incumbent free to price as it sees fit. Even if the entrant does enter, the incumbent could respond by lowering its price, thus deterring consumers from switching. The self-correcting process of the market is therefore likely to take longer to work, if it works at all.

Game theory has a role in post-Chicago analysis: this suggests that an incumbent may respond strategically to the threat of entry by choosing a strategy to ward off entry. For example, if entry is threatened the incumbent may increase output and reduce its prices to signal to the entrant that it has lower costs than it in fact has and thus makes the entrant unsure as to whether it can enter the market profitably.

This thesis accepts the post-Chicago school of thought. The sizable economies of scale and scope in fixed telecoms networks, and the switching costs faced by consumers, mean that entry and expansion by potential and actual rivals is unlikely in the event of monopolistic behaviour by the incumbent. Market imperfections, therefore, tend to be non-transitory and so can be, and indeed are, exploited by dominant firms for their own advantage. A firm that is dominant in a market characterised by high barriers to entry may abuse that position to cause harm to either its competitors or customers, or indeed to both, and it should be expected that, in the absence of competition law and/or regulation, it would do so. Rivals will not be able to respond to anticompetitive actions in the short run due to those barriers to entry. It is possible that the market may be self-correcting in the long run, but this would only come about with a change in technology that reduces barriers to entry and expansion. Regulatory authorities must, therefore, ensure that the dominant firms' ability to behave in such a manner is constrained for the benefit of competition and the consumer.

2.3   Abuse of a Dominant Position

There are, broadly, two types of harm: exploitative and exclusionary, and these can be imposed via either horizontal or vertical restraints. This thesis is concerned with a particular exclusionary harm via a vertical restraint: discrimination, which will be discussed in more detail later in this section. Other forms of harm are introduced here to place discrimination in the wider context.

Horizontal restraints refer to agreements between firms operating at the same level of the value chain that potentially lead to a lessening of competition in the market. Such agreements include cartels and mergers that create a dominant firm. In both cases the market power of a firm increases, allowing the merged entity or the cartel to set prices and output at the monopoly level and/or to exclude other competitors from the market.

Vertical restraints refer to agreements and practices between undertakings at different levels of the value chain. In this case, contracts are often governed by provisions that not only set more general terms of payments, but also include terms that limit one party's decisions or that soften competition (Rey and Vergé,

2008). Vertical restraints can be imposed by a firm that operates at only one level of the value chain and exerts those restraints on a firm at the next level, or by a vertically integrated firm that operates both upstream and downstream against its downstream rivals, as illustrated in Figure 2.

Figure 2: Vertical Relationships
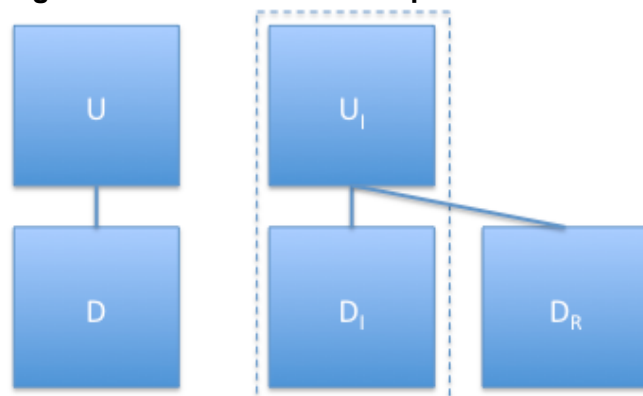
The upstream and downstream firms on the left hand side of Figure 2 are separately owned, whereas on the right hand side, U_I and D_I are part of the same vertically integrated firm and D_R is a downstream rival that is dependent on the integrated firm for the upstream input.

Whereas horizontal restraints tend to lessen competition in a market directly, in a vertical restraint it is likely that competition will only reduced if one of the firms already has market power and uses that power to constrain the behaviour of a vertically related firm. Of course, under a horizontal constraint once the merged entity or cartel has lessened competition and gained more market power, it can use that additional power to harm consumers and rivals.

Exploitative behaviour is generally aimed directly at consumers and refers to setting prices substantially above an appropriate measure of cost[11], and at the extreme at the monopoly level, to take advantage of the fact that consumers have little or no choice of alternative suppliers. There is some discussion in literature on "fair pricing" (Maxwell, 2008) and "excessive pricing" (Fletcher and Jardine, 2007). As Fletcher and Jardine point out, assessing what is an excessive price is hard: what should the benchmark (non-excessive) price be? If the competitive price, what is that level? What should be the allowed magnitude of any margin above the competitive price? They also point out that regulating a price so that it is not excessive may itself be distorting. Determining what is exploitative behaviour, therefore, is something that may sound simple in concept, but can prove problematic in practice.

Exclusionary behaviour is generally aimed at competitors of the dominant firm with the effect of preventing them from competing effectively in the market. Most European cases of abuse of dominance refer to exclusionary conduct. However

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[11] For example, marginal cost of Long Run Incremental Cost (LRIC).

once a dominant firm successfully excludes a competitor, it can immediately exploit consumers (Vickers, 2008). Some forms of exclusionary behaviour are discussed briefly below.

Predatory pricing refers to a dominant firm setting its prices below some measure of cost with the effect or intention of forcing competitors out of the market. The appropriate cost standards were first set out in Areeda and Turner (1975) and a similar benchmark was set by the European Court of Justice (ECJ) in a case known as *Tetra Pak II*:

> *"First, prices below average variable cost must always be considered abusive. In such a case, there is no conceivable economic purpose other than the elimination of a competitor, since each item produced and sold entails a loss for the undertaking. Secondly, prices below average total costs but above average variable costs are only to be considered abusive if an intention to eliminate a competitor can be shown."[12]*

The relevant cost standard has been developed further by the European Commission to include the Average Avoidable Cost (AAC). In its guidance on Article 82 (now 102), the Commission states that "pricing below AAC will in most cases be view by the Commission as a clear indication of [profit] sacrifice" (European Commission 2009, para. 64).

Under European law, it is not necessary to demonstrate that the dominant firm had any intention or prospect of recouping any loss made during a period of predatory pricing. The mere act of pricing below cost to drive out competition is sufficient.

A *margin squeeze* occurs when a vertically integrated dominant firm sets the wholesale price for an upstream product, on which the downstream rivals rely, and the retail price for its final product such that the margin between them is unduly narrow, thereby anti-competitively squeezing rivals downstream. The wholesale price may be unduly high relative to the retail price or the retail price may be unduly low relative to the wholesale price (Vickers, 2008). The vertically integrated firm can choose where it takes it profits (upstream or downstream) whereas the rival can only make profits in the downstream business.

Predatory pricing and margin squeeze are examples of price-based exclusionary practices. Non-price practices include tying, bundling, exclusive dealing, refusal to supply and foreclosure or discrimination[13]. Brief descriptions of the first four of these behaviours are given below and then a longer description of discrimination is set out in Section 2.4, as discrimination is the anti-competitive practice of concern to this thesis.

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[12] Case C-333/94P Tetra Pak International SA v. Commission [1996] ECR I-5951, para. 41.

[13] "Discrimination" and "Foreclosure" are sometimes used interchangeably. However, in this thesis the term "discrimination" will be used as it more accurately describes the practice explored here of treating internal and external customers differently. "Foreclosure" has a more absolute implication as it suggests completely refusing access to a competitor.

Tying requires the downstream firm to buy one or more goods from the upstream firm over and above that which the downstream firm initially requires or where competitive alternatives are available. For example, a publican may wish to rent premises from a brewery but can only do so if he or she also agrees to buy beer and other drinks as well. In so doing the brewery excludes its competitors from the pub.

Although normally considered an exclusionary behaviour, tying can also be exploitative when aimed directly at consumers. For example, if the publican wanted to rent the pub from an independent property company rather than a brewer, the property company may also insist that he or she buys beer and other drinks through the company at exploitative prices.

Bundling is similar to tying but requires the downstream firm, or the consumer, to purchase products together that it may wish to purchase separately. In many cases bundling is efficient and not anti-competitive: a car, for example, is a bundle of goods that are rarely if ever sold separately. It can be an anti-competitive practice, however, if a firm bundles together a product on which it has market power with a competitive product and only provides them as a bundle. Here the dominant firm is said to be leveraging its dominance from one market to another. For example, a telecoms company that provides both fixed and mobile communications may be dominant in the former and face competition in the latter. By bundling the two together it can leverage its dominance from fixed to mobile.

Exclusive dealing at its crudest is simply a dominant firm requiring a downstream buyer to purchase all of its requirements of the relevant product or service from the dominant firm, thereby excluding all competitors from the market. More subtle forms of exclusive dealing include discount and rebate schemes that reward the downstream firm for buying from the dominant firm. The *Michelin II* case[14], discussed in Motta (2009) is an example of such a scheme. The essence of this scheme was that once a distributor had purchased a certain volume of tyres from Michelin, the rebate on further purchases meant that the marginal cost of additional tyres became negative. Thus the distributor had a strong incentive to purchase only from Michelin and not from its rivals.

Refusal to supply is almost self evident: it refers to the blanket refusal by the owner of an essential facility to supply goods or services to another firm. Motta provides an example.

> *"Imagine for instance that a shipping company X integrates backwards and builds new port installations in a certain town A, located in the "home" country. Given the location, using this port's infrastructure gives firm X a great advantage in serving the maritime route from the home country to a*

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[14] Case T-203/01, Manufacture francaise de pneumatiques Michelin v. Commission, 2003.

*certain other foreign country. Company Y now requests use of the port
and firm X denies it (refusal to supply)."* (Motta, 2004, p.67)

A subtler version of refusal to supply is by unduly delaying supply through what
could be termed "strategic incompetence". Here the dominant firm places so
many procedural barriers in the way to supply, for example by claiming a lack of
capacity, that the purchasing firm's competitive position is weakened by the time
it is finally supplied.

The examples of anticompetitive practices discussed above are by no means an
exhaustive list and, indeed, this section is not intended to be exhaustive. Rather it
gives a flavour of the behaviours that a dominant firm may exhibit to exploit its
position and to exclude rivals from entering or expanding within the market. One
behaviour that has not been discussed above, but is the behaviour of interest to
this thesis, is a dominant, vertically integrated firm's different treatment of its own
retail business and its rivals in the downstream market: discrimination.

2.4 Discrimination

2.4.1 The Meaning and History of "Discrimination"

In Europe, discrimination, in a general sense, makes an early post-war
appearance in the European Convention on Human Rights (ECHR), which states
in Article 14:

> *"The enjoyment of the rights and freedoms set forth in this Convention
> shall be secured without discrimination on any ground such as sex, race,
> colour, language, religion, political or other opinion, national or social
> origin, association with a national minority, property, birth or other status."*

A more detailed legal interpretation can be traced back to the "Belgian Linguistic"
case[15], the Marckx judgement in 1979[16] and the Van der Mussele case of 1983[17].
In Belgian Linguistics, the European Court of Human Rights held that "the
principle of equality of treatment is violated if the distinction has no objective and
reasonable justification" (para. 10). In the Marckx judgement the ECHR stated
that Article 14 of the European Convention on Human Rights "safeguards
individuals, placed in similar situations, from any discrimination in the enjoyment
of the rights and freedoms set forth in those other provisions" (para. 32). In Van
der Mussele the ECHR said that "Article 14 safeguards individuals, placed in
analogous situations" (para. 46).

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[15] Case "Relating to Certain Aspects of the Laws on the use of Languages in Education in Belgium"
v. Belgium (Merits) (Application no 1474/62; 1677/62; 1691/62; 1769/63; 1994/63; 2126/64),
23rd July 1968.
[16] Marckx v Belgium, European Court of Human Rights 6833/84, 13th June 1979.
[17] Van der Mussele v Belgium (1983) EHRR 163, 179 – 180, 23rd November 1983.

In a House of Lords judgement from 2005[18], Lord Hoffman gave as clear a definition of discrimination as one is likely to find:

> *"Discrimination means a failure to treat like cases alike. There is obviously no discrimination when the cases are relevantly different. Indeed, it may be a breach of article 14 not to recognise the difference."*

A legal bar on discrimination does not mean that all individuals need to be treated in exactly the same way. Rather the case law points towards different treatment being allowable where the situation is not analogous as such difference in treatment is not discriminatory. As Lord Hoffman pointed out, treating people in non-analogous situations in the same way could itself be discriminatory.

The economic interpretation of discrimination is consistent with this approach. In his seminal article, Kenneth Arrow describes discrimination as some characteristic of an employee other than productivity that would account for differences in wages for the same job. Arrow considers the case of different ethnic groups working in steel production, and writes:

> *"The black steel worker may be thought of as producing blackness as well as steel, both evaluated in the market. We are singling out the former as a special subject for analysis because somehow we think it appropriate for the steel industry to produce steel and not for it to produce a black or white workforce."* (Arrow, 1973, p. 2)

With respect to the production of steel, the black and white worker are alike and should therefore be treated in a like manner for one or other not to be discriminated against. Any difference in treatment due to skin colour would be discriminatory. However, should one or other have a higher productivity and therefore be paid more (if the two workers are on performance related pay) then, provided such difference in pay is based on their performance rather than colour, the pay difference would not be discrimination. The less productive worker would have the opportunity to earn more if he/she increased his/her productivity regardless of the colour of their skin.

When firms sell products and services, discrimination refers to the provision of those goods or services under different conditions even though customers are in equivalent circumstances. The opportunity for a dominant firm to behave in this way can arise from its market power, affording it the ability to treat equivalent customers differently. To adopt Arrow's language, discriminated against customers may be considered to be consuming some sort of difference when it is appropriate for them only to be considered as consuming the product or service.

A special case of discrimination, and the one most relevant to this thesis, is when a dominant firm behaves in such a manner to extend its position in one market to

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[18] Regina v. Secretary of State for Work and Pensions (Respondent) ex parte Carson (Appellant) [2005] UKHL 37.

a closely related market where it faces competition. Rey and Tirole provide a definition of this behaviour (although they use "foreclosure" instead of "discrimination"):

> *"[F]oreclosure refers to a dominant firm's denial of proper access to an essential good it produces, with the intent of extending monopoly power from that segment of the market (the bottleneck segment) to an adjacent segment (the potentially competitive segment). Foreclosure can arise when the bottleneck good is used as an input (e.g. an infrastructure) by a potentially competitive downstream industry, or when it is sold directly to customers, who use the good in conjunction with other, perhaps complementary goods (e.g. systems goods or after sale service)."* (Rey and Tirole 2007, p.1)

Discrimination can take two forms: price and non-price.

Price discrimination exists when a firm sells two similar products with the same marginal cost at different prices to different customers (Armstrong, 2008). He also refers to Stigler's (1987) definition: discrimination exists when two similar products are sold at prices that are in different ratios to their marginal costs. The reverse is also true: discrimination would occur if different products, with different costs, were sold at the same price. Phlips says that:

> *"[P]rice discrimination should be defined as implying that two varieties of the same commodity are sold (by the same seller) to two buyers at different net prices, the net price being the price (paid by the buyer) corrected with the cost associated with the product differentiation."* (Phlips, 1983, p.6)

Anti-competitive price discrimination was originally made unlawful in the United States in the Clayton Act (1914) Section 2, which expressly banned such behaviour if its effect was a substantial lessening of competition. The Clayton Act prohibited price discrimination, the effect or intent of which "may be to substantially lessen competition or tend to create a monopoly in any line of commerce." The Act was directed at predatory price cutting that eliminated competition among sellers (Rowe, 1951).

This Section, however, was amended in 1936 and became the Robinson-Patman Act, also known as the Anti-Price Discrimination Act. According to Rowe (1951, p. 929), chain stores and their ability to obtain lower prices from suppliers than their smaller, independent rivals were the original "legislative target" of the Act, but it was widened to all industry. The Clayton Act's focus on competition among sellers was considered insufficient to prevent a lessening of competition among buyers. Section 2 of the Robinson-Patman Act requires sellers to sell to all downstream firms at the same price, and also places an obligation on buyers to buy from a seller at the same price as everyone else, provided the buyer has the requisite knowledge (Clark, 1998).

Armstrong (2008) gives three reasons why competition policy may be concerned with price discrimination. First, a dominant firm may exploit final consumers resulting in a loss of consumer welfare. Secondly, in the EU context, price discrimination may affect the single market if the same product is sold at different prices in different member states. Thirdly, price discrimination may be used to exclude or weaken actual or potential competition.

It is this third reason that is most relevant to this thesis. Here a vertically integrated incumbent that is dominant in the market for the upstream product may set an external price for the input that is higher than its internal costs. Thus the entrant faces a higher input cost than the incumbent's own downstream business. Armstrong says that assuming the same input cost is the non-discriminatory cost would be "naïve" and that the actual non-discriminatory price should also take account of the opportunity cost to the incumbent of not earning the profit on the retail product. Thus the non-discriminatory wholesale price (a) is:

$$a = c_2 + (p - c_1)$$

Where c_2 is the marginal cost of supplying the input to wholesale customers, c_1 is the marginal cost of supplying the good to consumers and p is the retail price.

The non-discriminatory price proposed by Armstrong is equivalent to the Efficient Component Pricing Rule (ECPR), in which the entrant compensates the incumbent for the opportunity cost to the incumbent of lost business. This ensures that the entrant can only enter the market profitably if it is at least as efficient as the incumbent and so resources are not diverted to an inefficient producer (Economides and White 1995).

Non-Price Discrimination refers to the provision of different non-price terms, for example delivery times, to internal and external customers. Non-price discrimination and the remedies imposed by regulators to deter such behaviour are the main subject of this thesis.

Non-price discrimination, which is sometimes also referred to as "sabotage" and one form of which is "raising rivals' costs" (RRC), is of particular concern when a vertically integrated firm is selling to downstream rivals. Beard, Kaserman and Mayo (2001) define sabotage as "a quality reduction that raises the costs of the non-integrated downstream producers", and may take many forms. At one extreme, the vertically integrated firm can, in the absence of regulation to prevent such behaviour, refuse to supply an essential input over which it has a monopoly, thus foreclosing the retail market to any rival. Such outright refusal to supply is generally prohibited by the law and in utility sectors the incumbent is placed under an obligation to provide access. Even in the presence of such an obligation, the vertically integrated incumbent can provide access under different, less favourable terms and conditions to its rivals than it does to its downstream affiliates or division. Provided such difference in treatment is not objectively justified, and like cases are not treated alike, then such difference in treatment is discrimination.

Among the first papers to explore the issue of raising rivals' costs (RRC) through non-price means was Salop and Scheffman (1983). In this early contribution, the authors demonstrate that a strategy adopted by a dominant firm that raises the costs of its rivals is likely to have an advantage over a predatory pricing policy, as it is better to compete with a high cost rival, and short term profits do not have to be sacrificed.

Krattenmaker and Salop (1986) undertook a thorough analysis of RRC in the context of US antitrust law decisions at the time. They identified four such strategies that they considered "legitimate" (as opposed to "discredited"):

1. Bottleneck: The purchaser obtains exclusive rights of supply from low cost producers such that its rivals are forced to purchase from higher cost suppliers;
2. Real Foreclosure: This is similar to bottleneck, but in this case the purchaser deliberately overbuys a crucial input thus denying it to its competitors;
3. Cartel Ringmaster: A purchasing firm persuades suppliers to supply other customers on less favourable terms than it receives;
4. Frankenstein's Monster: The purchaser of an exclusionary rights contract creates a different industry structure that is likely to generate a price increase.

A later paper by Scheffman illustrates RRC theories in their simplest form. Figure 3 depicts a competitive industry with its supply curve made up of three segments: I_1, I_2 and M, and a demand curve DD. The I suppliers are infra-marginal and the M suppliers are marginal. The segment I_1 is the supply curve for a group of producers that have constant average and marginal costs of c_1 up to an output of Q_1, which is the absolute capacity limit for the I_1 producers. Similarly, I_2 is the supply curve for a group of producers that have constant average and marginal costs of c_2 up to an absolute capacity level of Q_2-Q_1. Finally, segment M is the supply curve for a group of producers who have constant average and marginal costs of c_m. As drawn, the M producers have no capacity limitations. The competitive price, c_m, and output, Q*, are depicted in Figure 3. At a price of c_m, the I_1 and 1_2 firms are inframarginal, i.e., although they are acting competitively, price is above their average costs. Their earnings over average costs are termed "inframarginal rents."

Figure 3: Raising Rivals' Costs
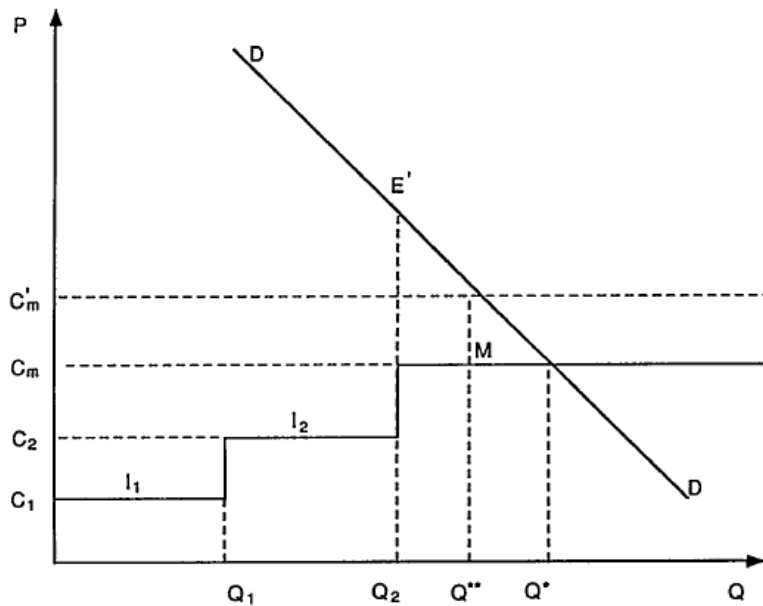
(Scheffman, 1992, p. 191)

In this example, the inframarginal firm takes some action to raise the unit costs of the M producers to c'_m, but leaves the costs of the l_1 and l_2 producers unchanged. The M producers' supply curve is shifted upwards, resulting in an increase in the market price to c'_m, and a reduction in industry output to Q**. The basic principle is that prices in competitive markets are determined by industry marginal costs (and demand), so that prices increase with increases in industry marginal costs, as long as demand is not highly elastic (Scheffman, 1992, p. 191 – 192).

In Scheffman's example l_1 and l_2 are both inframarginal, as the demand and supply curves intersect to the right of the vertical line E'Q$_2$. However, if the market demand curve was more elastic then l_2 could become a marginal producer if Q** were to be moved to the left of Q$_2$.

Later on, this thesis will explore, and attempt to calculate, by how much BT was able to raise the costs of rivals in the broadband market or, more accurately, by how much rivals must have perceived those costs to have been raised and restricted their entry accordingly. In the context of Figure 3, BT is l_1 and the thesis will attempt to determine by how much its rivals, the M producers, had their unit costs raised from c_m to c_m'.

2.4.2 Incentives to Discriminate

Section 2.2 examined why, in general, a dominant firm might wish to abuse its position. This section is more specific and examines the circumstances in which a vertically integrated firm that is dominant in the upstream market would have an incentives to discriminate against downstream rivals.

This question has been addressed in the literature on discrimination. Beard et al (2001) find that the incentive for sabotage by a regulated vertically integrated firm

depend upon: (1) the margin between the regulated price and cost at the upstream stage, (2) the price-cost margins at the downstream stage, and (3) the intensity of competition in the upstream market. However, they also say that the existence of an upstream fringe (condition 3) is not necessary to establish the profitability of sabotage.

Kondaurova and Weisman (2003) develop a methodology to estimate the likelihood that the incentive to discriminate will arise in equilibrium, based on a given distribution of firm-specific own and cross-price elasticities. They find that the number of cases in which discrimination arises is very sensitive to initial market shares and downstream prices. In line with Beard et al, their simulations also reveal that when the access price is close to marginal cost, the number of discrimination cases remains very large, even if all other parameters are conducive to non-discrimination outcomes. Access charge reductions are therefore likely to exacerbate the incentive for non-price discrimination in an environment in which the regulator's ability to monitor discrimination is imperfect.

Mandy and Sappington (2007) examine incentives for an integrated firm to discriminate against (sabotage) rivals in a downstream market under both Cournot and Bertrand competition. They identify two types of sabotage: cost increasing and demand reducing, though they do not give examples of specific behaviours which might fall into these categories. In their models the integrated firm faces a trade-off. If it sabotages its downstream rival such that its demand for the wholesale input is reduced, will it be able to off-set those losses by increased demand and profits from its own downstream affiliate?

They find unambiguously that the integrated firm's profits rise under Cournot competition using both cost-raising and demand-reducing sabotage. The integrated firm is able to raise its profits from its own downstream operations sufficiently to off-set any loss from reduced demand by the rival downstream firm. However, under Bertrand competition the results are mixed. Cost-raising sabotage is profitable, but demand-reducing sabotage may not be. Mandy and Sappington find that if the rival's demand is reduced, it will respond by lowering its prices to increase demand which will take revenue away from the affiliate. Thus demand-reducing sabotage under Bertrand competition would reduce the profit of the integrated firm and so would not be undertaken.

An interesting area of debate in the foreclosure literature is whether the vertically integrated firm would still have an incentive to discriminate if the downstream rival was more efficient. The more efficient rival could set a lower retail price, expand the market and therefore generate more wholesale revenue for the integrated firm. That debate is summed up in Mandy:

> "Economides (1998, Proposition 3 (p. 281)) concludes that severe sabotage will occur, to the point of downstream market foreclosure, even if the monopolist's downstream rivals are more efficient than its downstream subsidiary. In another model, Weisman (1995) finds that there are circumstances which may cause the integrated firm to temper its

level of sabotage. Weisman (1999) finds that the incentive to engage in sabotage is theoretically ambiguous when the monopolist's downstream rivals are more efficient than its downstream subsidiary." (Mandy, 2000, p.158)

Mandy himself concludes: "an upstream monopolist would be 'killing the (downstream) goose that laid the golden egg' if it conducted sabotage against relatively efficient downstream rivals when its upstream margin is high and its downstream subsidiary's margin is low" (Mandy, 2000, p.171). It is in the second half of this sentence that the answer to the question lies: whether the vertically integrated firm would wish to harm a more efficient downstream rival is an empirical question. If the profits on the extra sales it earns from accommodating the downstream rival outweigh the profits it would earn from excluding the rival and taking the profit itself, then it would have no incentive to discriminate. If, on the other hand, it could earn more profit from the retail sales then the incentive to discriminate is still present.

Under the "one monopoly profit" theory, the vertically integrated firm would have no incentive to discriminate against downstream rivals if it were able to set the monopoly price for the upstream product. As it could not earn any more profit if it were also the downstream monopolist, it would therefore be indifferent between retailers in a perfectly competitive retail market, all of whom earned zero profits. However, if its upstream profits are constrained in some way, for example through price regulation, then it has an incentive to discriminate to earn extra profits in the retail or intermediate markets.

Overall, previous literature indicates that the incentives for sabotage are dependent upon profitability of the upstream input and the relative efficiency of downstream rivals. Below are four conditions of upstream and downstream profitability and their effect on the incentive of the integrated firm to discriminate. In all four conditions p = retail price, q = quantity, w = wholesale price and c = the marginal cost of the upstream product supplied to both internal and external retailers. The subscripts 1 and 2 refer to the integrated firm and its downstream rival respectively. The integrated firm produces an input at cost c, which it uses itself to provide a retail service and which it sells to its downstream rivals at a wholesale price, w. In some conditions below $w > c$ and in other $w = c$. The margin between the wholesale price and the marginal cost affects the incentive of the integrated firm to discriminate in essence because the higher the proportion of profits earned from wholesale sales, the lower the incentive to harm downstream rivals who generate profits.

The profits earned by the integrated firm and its downstream rival are as below:

$$\pi_1 = q_1(p_1 - c) + q_2(w - c)$$

$$\pi_2 = q_2(p_2 - w)$$

Condition 1: $p_1 = p_2$, $q_1 = q_2$ and $w = c$.

The integrated firm earns zero profits from sales to independent retailers. It can therefore only maximise its profits by excluding its rivals from the market and so has the maximum incentive to discriminate.

Condition 2: $p_1 = p_2$, $q_1 = q_2$ and $w > c$.

The integrated firm earns positive profits in both wholesale and retail markets but earns higher profits when it is active at retail level. It therefore still maintains an incentive to discriminate but this will be weaker than in condition 1. The strength of the incentive depends on the relative margins at the wholesale and retail level.

Condition 3: $p_1 > p_2$, $q_1 < q_2$, $w > c$. $(q_1 + q_2^*) > (q_1 + q_2)$

In this condition, the rival is more efficient than the incumbent and so able to set a lower retail price and so sell a larger quantity than the incumbent. The greater efficiency of the rival extends the market size through a lower price. Whereas under conditions 1 and 2 $Q = q_1 + q_2$, now $Q = q_1 + q_2^*$, where q_2^* is the increased quantity sold by firm 2 as a result of its lower price.

The integrated firm's profits from the wholesale are now increased by $q_2^* - q_2(w - c)$. Dependent on the increase in volume and price:cost ratios, the integrated firm may earn higher profits from wholesale than retail activities and may therefore even wish to exit from the retail market. This is similar to the conditions in Sibley and Wiseman (1998) where they found the incumbent's incentive to discriminate disappears once its market share falls below 26%.

Condition 4: At t(0), $p_1 > p_2$, $q_1 < q_2$, $w > c$. At t(0+1), $p_1 = p_2$, $q_1 = q_2$ and $w > c$.

The vertically integrated firm could respond to the entrant's greater efficiency in one of three ways. First, by becoming more efficient itself in the downstream market and the incentives to discriminate therefore revert to Condition 2. At *t(0+1)* market prices are lower and quantities correspondingly higher, dependent on the slope of the demand curve. Secondly, it could raise its rivals costs such that at *t(0+1)* $p_1 = p_2$ but at the incumbent's old price leading to a reduction in q_2. Finally, the incumbent could acquire the more efficient entrant and so internalise the increased efficiency, assuming it has the capability to do so.

2.5   Vertical Integration and Separation

Firms constantly face decisions about how vertically integrated they should be (Gómez-Ibáñez, 2003) and the reasons why firms decide to be vertically integrated or not has been the subject of extensive academic research since R.H. Coase's seminal article of 1937. Many researchers have taken his thinking forward both theoretically and empirically. Among the most influential are Williamson (1979, 1985); Grossman and Hart (1986); and Klein, Crawford and

Alchian (1978). There have also been a number of articles reviewing the literature and the empirical testing of the various theories (Lafontaine and Slade, 2007; Carter and Hodgson, 2006; Whinston, 2003; Shelanski and Klein, 1995; and Carter, 2012).

According to Lafontaine and Slade, the literature has focused on two interrelated questions. First, under what circumstances do we observe that an input or service is produced in-house? Secondly, what are the consequences of vertical integration for economic outcomes such as prices, quantities, investment and profits? They then refer to four models which identify the circumstances in which firms are likely to integrate.

Under the "moral hazard" model, individual workers choose employment, even though they may earn less than if they were freelance, because employment provides some insurance. "Moral hazard arguments for firm boundaries thus emphasise the trade-off between providing insurance, which firms do well, and with effort incentives, which markets do well" (Lafontaine and Slade, 2007, p.633).

The second set of models reviewed by Lafontaine and Slade are Transaction Cost (TC) models, which date back to Coase and have been developed by Williamson and by Klein, Crawford and Alchian. TCs are the costs of establishing and administering business relationships within and between firms and individuals. The fundamental insight of TC models is that parties to a transaction often make investments that have greater value inside than outside the relationship. Thus, the value of the assets in their intended use is higher than their value in an alternative use.

Williamson (1979) draws the distinction between "idiosyncratic" (relationship specific) and non-specific investments. He describes the crucial distinction between the two as the degree to which transaction-specific (non-marketable) expenses are incurred. Unspecialised items cause few hazards since buyers can turn to alternative suppliers, and suppliers can find alternative uses or customers for their assets. Non-marketability problems arise when the specific identity of the parties has important cost-bearing consequences.

Lafontaine and Slade point out that there is a potential problem when asset investments are relationship specific. This is that there are likely to be quasi-rents and each of the parities has incentives to capture those rents for themselves. They are therefore likely to haggle after the investment has been made. The buyer, for example, may seek a lower price knowing that the supplier has no better alternative use for the asset. This problem is known as the "hold-up problem".

Well-specified contracts may protect each party, but it is unlikely that contracts will be "complete" and cover every possible eventuality. It also raises the costs of contracting.

TC theories usually assume that the hold-up problem can be mitigated within the firm. Thus the likelihood of integration is likely to increase when relationship specific investments are made. By contrast, separation would lead to the hold-up problem when investments are relationship specific.

The third model form Lafontaine and Slade discuss is the Property Rights Theory (PRT). Although PRT and TC are often thought to be closely related, Whinston (2003) points to three differences between the two. First, PRT is more formal than TC. Secondly, PRT focuses on distortions in *ex ante* investments, in contrast to the *ex post* hagglings and maladaption costs of TC. Thirdly, PRT assumes that the hazard is present in all organisational forms, including when a transaction takes places within a firm. This is so, because investment and trading decisions remain decentralised in PRT, regardless of the structure of asset ownership. Integrated asset ownership changes incentives, but does not result in coordinated investments as it does in TC models.

The fourth set of theories reviewed by Lafontaine and Slade concerns market power arising from vertical integration. These include: double marginalisation, strategic delegation and collusion, foreclosure and price discrimination. These theories provide few unambiguous results. Vertical mergers can be beneficial when the motive is to eliminate double marginalisation. However, when a firm has market power it can obtain the same results through vertical restraints rather than integration. For example, firms can eliminate double marginalisation through two-part tariffs, maximum resale prices or quantity forcing.

The alternative to vertical integration is, of course, separation. Martin Cave discusses forms of separation and describes "six degrees" between accounting separation at one extreme and full ownership separation at the other, shown in Figure 4 below (Cave, 2006, p.6).

Figure 4: Six Degrees of Separation

Ownership separation (in whole or part)
6 – Legal separation (separate legal entities under the same ownership)
5 – Business separation with separate governance arrangements
4 – Business separation with localised incentives
3 – Business separation (BS)
2 – Virtual separation
1 – Creation of a wholesale division
Accounting separation

Mark Jamison and James Sichter draw on experience from the Computer Inquiries, the break up of AT&T and experience of Netcos and RetailCos in Rochester (NY) and Pennsylvania to draw lessons on business separation. They say that a "primary motive for separating lines of business is to limit the ability of

an operator that controls bottleneck facilities to use that control to discriminate against rivals in competitive or potentially competitive markets". (Jamison and Sichter, 2010, p.1) .

They distinguish between four forms of vertical separation: ownership (divestiture), structural (separate legal entities within the same group [19]), functional or operational separation (competitive market functions operate separately from non-competitive functions) and accounting separation (separate accounts for the competitive and non-competitive functions).

There have been many articles that discuss separation in the context of the UK telecoms market, some of which will be reviewed later in the Section on functional separation in the UK.

2.6   European and UK Remedies

2.6.1   Law and Interpretation

Anticompetitive practices by firms in the supply of goods and services are specifically and explicitly prohibited under the EU treaties. Article 102 TFEU (formerly Article 82) prohibits the abuse of a dominant position by a dominant firm. Part (c) refers to discrimination.

> *"Any abuse by one or more undertakings of a dominant position within the internal market or in a substantial part of it shall be prohibited as incompatible with the internal market in so far as it may affect trade between Member States.*
> *Such abuse may, in particular, consist in:*
> *(a) directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions;*
> *(b) limiting production, markets or technical development to the prejudice of consumers;*
> *(c) applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage;*
> *(d) making the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts."*

Equivalent legal conditions can be found within the UK competition law, specifically the Competition Act 1998, which states at Section 18:

> *"(1) … any conduct on the part of one or more undertakings which amounts to the abuse of a dominant position in a market is prohibited if it may affect trade within the United Kingdom.*

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[19] Cave (2006) refers to this form as "legal separation".

> *"(2) Conduct may, in particular, constitute such an abuse if it consists in—*
>> *(a) directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions;*
>> *(b) limiting production, markets or technical development to the prejudice of consumers;*
>> *(c) applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage;*
>> *(d) making the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of the contracts."*

Note that Part 2(c) refers to discriminatory behaviour that places trading parties at a competitive disadvantage.

In 2009, the European Commission published guidelines on its enforcement priorities in relation to what was then Article 82. One such exclusionary practice identified by the Commission was foreclosure. The Commission defined anti-competitive foreclosure as:

> "*a situation where effective access of actual or potential competitors to supplies or markets is hampered or eliminated as a result of the conduct of the dominant undertaking whereby the dominant undertaking is likely to be in a position to profitably increase prices to the detriment of consumers.*" (European Commission, 2009, para 19)

The use of the phrase "hampered or eliminated" by the Commission appears to include both outright refusal to supply ("eliminated") and discrimination ("hampered") and certainly the Commission has investigated cases of abuse of a dominant position under Article 102 that stop short of refusal to supply, for example the Telecom Poland case discussed in Section 3.5.

The guidelines list a number of specific forms of abuse that the Commission will investigate (Para 32 onwards):

- Exclusive dealing;
- Tying and bundling;
- Predation; and
- Refusal to supply and margin squeeze;

The guidelines say that in applying Article 82 (now 102), the Commission will focus on conduct that is most harmful to consumers and that it will "*direct its enforcement to ensuring that markets function properly and that consumers benefit from the efficiency and productivity which result from effective competition between undertakings*" (Para 5).

The UK Competition Commission (CC), subsequently replaced by the Competition and Markets Authority (CMA), also issued guidance on market investigations (Competition Commission, 2013). This guidance recognised the potential for a vertically integrated firm with upstream dominance to foreclose competition downstream (paras. 265-285). However, it also recognised that vertical integration may be beneficial to consumers and so stated:

> *"In reaching a judgement on whether a particular vertical relationship has an adverse effect on competition, the CC will evaluate its overall impact on competition, taking into account rivalry-enhancing, as well as adverse, effects."* (Competition Commission, 2013, para. 273

2.6.2 Behavioural, Structural, and Quasi-structural Remedies

Remedies and obligations imposed by sector regulators and competition authorities can be either behavioural or structural. That is to say, they may either seek to restrict a dominant firm's behaviour directly or change its structure and, therefore, its incentives and ability to behave in certain ways that would be harmful to competition and to consumer welfare. Massimo Motta clearly distinguishes between structural and behavioural remedies:

> *"Structural remedies modify the allocation of property rights: they include divestiture of an entire ongoing business, or partial divestiture. Behavioural remedies set constraints on the merged firms' property rights: they consist of engagements by the merging parties not to abuse certain assets available to them or to enter into specific contractual arrangements."* (Motta, 2004, pp. 265-266)

Behavioural remedies "consist mainly of commitments aimed at guaranteeing that competitors enjoy a level playing field in the purchase or use of some key assets, inputs or technologies that are owned by the merging parties. Therefore, this situation mainly arises when the merged entity is vertically integrated" (Motta, Polo and Vasconcelos, 2007, p. 619). The principal behavioural remedies are designed to deter foreclosure by the merged entity in downstream markets through the granting of access to essential facilities on non-discriminatory terms. Motta et al. also refer to the possibility of a "vertical firewalls" remedy in which the integrated firm is required to protect competitively sensitive information supplied by its rivals to the upstream entity from the downstream entity.

Also in the context of mergers, Parker and Balto (2000) distinguish five approaches to curbing anti-competitive mergers: (i) blocking the merger from taking place; (ii) divestiture; (iii) partial divestiture; (iv) contractual arrangements such as licensing; and (v) a behavioural relief such as non-discrimination. Using Motta's taxonomy, the first three approaches above would be structural remedies and the final two are behavioural remedies.

Competition authorities in both the EU and the USA tend to favour structural remedies, in particular divestiture, in merger cases. The reason for this

preference is that divestiture does not require continuous monitoring by the competition authority to ensure compliance. As Motta et al. confirm: "in general structural remedies are the best corrective measures for potentially anti-competitive mergers" (p.610). Divestitures, once implemented, do not require any further monitoring measures whereas other types of commitments require effective monitoring mechanisms to ensure that their effect is not reduced or even eliminated by the parties. Otherwise, such commitments would have to be considered as mere declarations of intentions by the parties and would not amount to binding obligations (European Commission, 2007, para. 13.)

However, structural remedies are not without their problems. Motta et al. report five potential problems when divestiture is applied in merger cases. First, the merging parties have a strong incentive to ensure that the purchaser of the divested assets will not be a competitive firm. Secondly, the remedy is not good at fostering entry. Thirdly, whenever a continuing relationship is required between the seller and the buyer of the divested assets, the remedy has not managed to restore competition. Motta et al. refer to the Federal Trade Commission study (FTC, 1999) in which the FTC found that, in 13 of the 19 cases reviewed where such a relationship existed, either the buyer did not manage to operate effectively, or there was collusion between the two firms. Fourthly, the buyer is likely to follow a soft pricing strategy and tacitly or overtly collude with the seller. Fifthly, the risk of collusion increases due to problems of symmetry and multi-market contacts.

The most relevant of these five problems to vertical separation is probably the third as there will certainly be a continuing relationship between the owner of a separated access network and the owner of the core network business.

2.7   Conclusions from Chapter 2

This chapter has defined what is meant by dominance and shown how a firm that is dominant in one market can leverage that dominance into another related market. This is particularly the case when the firm is dominant in an upstream input that is required by downstream rivals to compete in the retail market. The presence of a vertically integrated firm, with a dominant position in the upstream market, therefore, places downstream rivals at risk from anticompetitive practices, one of which is non-price discrimination.

However, vertical integration has a number of efficiency benefits, in particular where there is a high degree of asset specificity, i.e. where the upstream input is highly tailored to one downstream customer: what Williamson described as "idiosyncratic". However, the problem of non-price discrimination has led to various levels of separation, described by Cave (2006) and ranging from Accounting Separation to full Structural Separation.

3   Application to the Telecommunications Sector

This chapter explores the problem of discrimination specifically within the context of the electronic communications market and shows how this problem is not only theoretic but has been found in practice in Poland. The chapter starts with a brief introduction to the telecommunications industry.

3.1   Introduction to Telecommunications

A telecommunications business can be thought of as consisting of three parts: a retail operation, an access network and a core or trunk network. In a fixed or mobile voice telephony network, access is at both "ends" connecting both the caller and receiver to the trunk or core network: this is known as "two way access" as each party could be either the caller or the receiver. Broadband access networks, whether fixed or mobile, tend to be one way, i.e. the "caller" connects to the Internet but not vice versa. One way and two-way access are illustrated in Figure 5.

Figure 5: One way and Two way Access
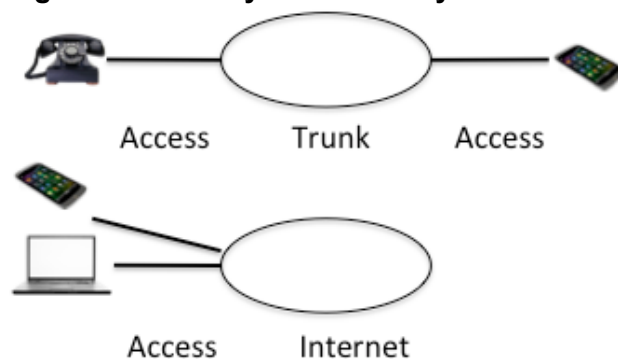
Access to the Internet over fixed networks has two levels: the physical connection (referred to as the "local loop"), which is generally a copper wire between the telephone exchange and the customer premises, and the electronic connection that sends a broadband signal over that wire and known as "bitstream access". Further downstream from bitstream is the retail operation.

The local loop has many characteristics of a natural monopoly, at least outside the most densely populated areas of a country[20]. It is usually too expensive for a second company to undertake the major civil engineering works required to build a competing network when each household normally buys only one connection. However, if an entrant can rent the local loop it can add its own electronics and so enter the market at the bitstream level. The entrant could also purchase bitstream access and operate only as a retailer. This market structure is shown in Figure 6 and is typical of the telecoms sector.

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[20] There are exceptions. For example, in the UK Virgin Media has a competing local access network covering approx. 55% of homes. However, this network was built for cable TV with telecoms only added later.

Figure 6: Vertical Structure of the Broadband Market
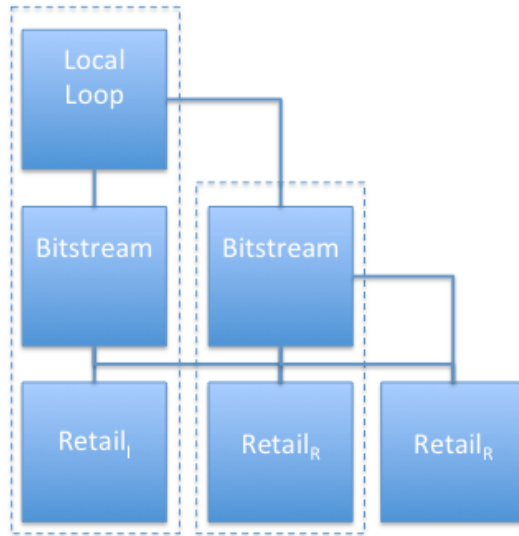
To facilitate competition using the incumbent's local access network, telecoms regulators have required dominant firms to provide several complementary access services. Figure 7 provides a simplified vision of the three forms of wholesale copper access for providing broadband Internet access.

Figure 7: Forms of Wholesale Copper Access

| Resale | Bitstream | Local Loop Unbundling |
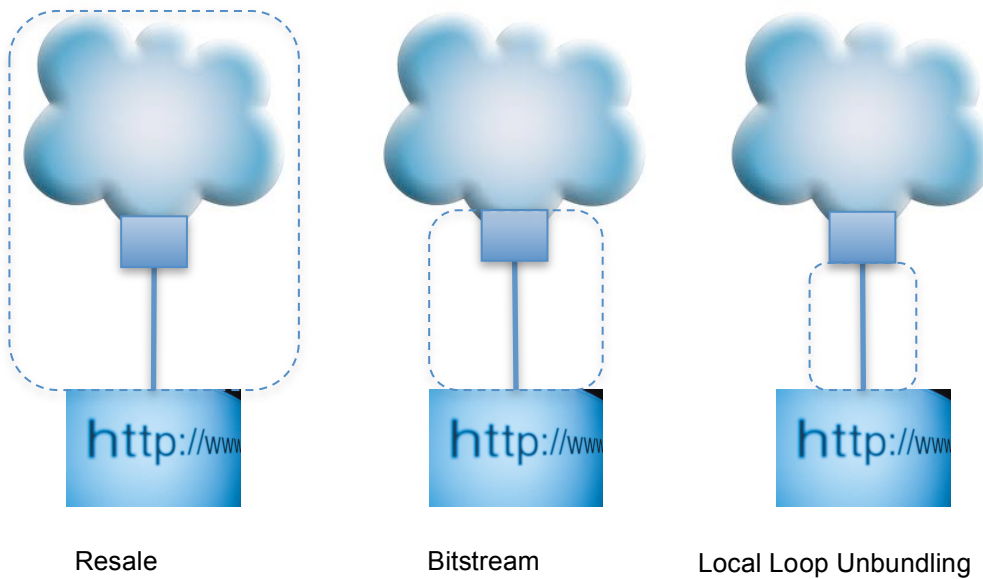
On the left is Resale Access (RA). Under this method, the entrant purchases both local access and the core network from the incumbent. The only way in which it can differentiate its services is through brand and price. The BT version of this access method is (was) known as IPStream.

The middle option is Bitstream Access (BSA), marketed by BT as DataStream. The entrant rents both the access network and the electronics that convert that access line into a broadband connection as a complete package. BT hands over (interconnects) with the entrants' own core network at or near the relevant

telephone exchange building. This option is also sometimes known as "near-end handover".

Finally, on the right, is Local Loop Unbundling (LLU). The entrant using LLU rents only the copper access network and must house its own electronics in or near the local telephone exchange, and must provide its own backhaul from the exchange to its own core network. LLU requires the highest initial investment by the entrant, but offers the greatest opportunity for differentiation.

Broadband over copper is provided using a technology known as Asynchronous Digital Subscriber Line (ADSL) of which there are several variants offering access speeds of up to 24Mbps dependent on the technology used and the distance from the exchange to the customer premises. This is thought to be the maximum speed that can be offered using copper from the exchange to the customer premises. ADSL is one form of DSL, which are collectively referred to as xDSL. Another form of DSL relevant to this thesis is VDSL (Very high bit rate DSL) that is used in conjunction with Fibre to the Cabinet (discussed below)

In many countries, including the UK, broadband access is also provided over the cable TV network in at least part of the country. Broadband over cable is provided using a technology known as Data Over Cable Service Interface Specification (DOCSIS) and offers much higher speeds than ADSL. The latest variant (DOCSIS3) offers speeds of up 150Mbps.

Finally, and more recently, fibre optic networks have been developed that offer broadband Internet access at much higher speeds than ADSL. Fibre access networks can run between the exchange building and several points before the premises, as illustrated in Figure 8. The four principal places are:

- Fibre to the Node (FTTN): Fibre is terminated in a street cabinet, possibly several kilometres away from the customer premises, with the final connections being copper.
- Fibre to the Cabinet (FTTC): This is very similar to FTTN, but the street cabinet is closer to the user's premises, typically within 300m, meaning that the distance the signal has to travel over copper is shorter, thereby offering higher speeds to the user. The signal over the final few hundred metres is sent using the VDSL protocol.
- Fibre to the Building/Premises (FTTB/P): Fibre reaches the boundary of the building, such as the basement in a multi-dwelling unit, with the final connection to the individual living space being made via alternative means, potentially an internal wired or wireless network.
- Fibre to the home (FTTH): Fibre reaches the boundary of the living space, such as a box on the outside wall of a home.

Collectively these different approaches are referred to as FTTX.

Figure 8: Fibre to the X Options
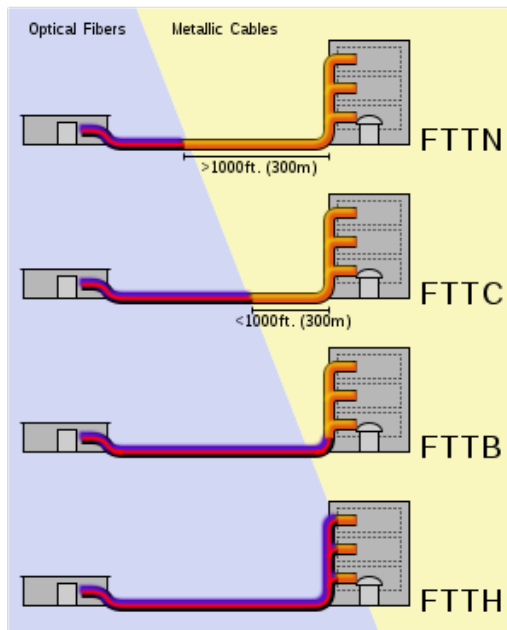
The main approach taken by BT is FTTC. Other EU countries have tended to choose between FTTC and FTTP, with only Finland and Sweden having a significant coverage of both technologies, as shown in Figure 9, which shows the proportion of premises covered by FTTC and FTTP in 2012.

The speeds available over the options vary from around 50Mbps to almost no upper bound for FTTH. However, for the purposes of this analysis, the exact form of FTTX or the bandwidth offered are not important, only the fact that BT decides to install FTTX in a particular exchange area.

In the UK, BT is the fully vertically integrated operator depicted on the left hand side of Figure 6. There are two major competitors to BT, Sky and TalkTalk, that rent local loops from BT and so enter at the bitstream level. Various smaller operators buy access from either BT or one of its competitors at the bitstream level. There is also an independent, fully integrated broadband provider, Virgin Media, that offers services over its Hybrid Fibre-Coax (HFC) cable network. In the context of Figure 6, Virgin Media is equivalent to BT but does not provide wholesale access to its network at any level. Virgin Media is not, and has never been, regulated in any part of its business on the basis that it does not have Significant Market Power (SMP) in any market.

Figure 9: Fibre Deployment Choices in EU Countries

Fibre Deployment Choices in EU Countries

(Legend: FTTP, FTTC)
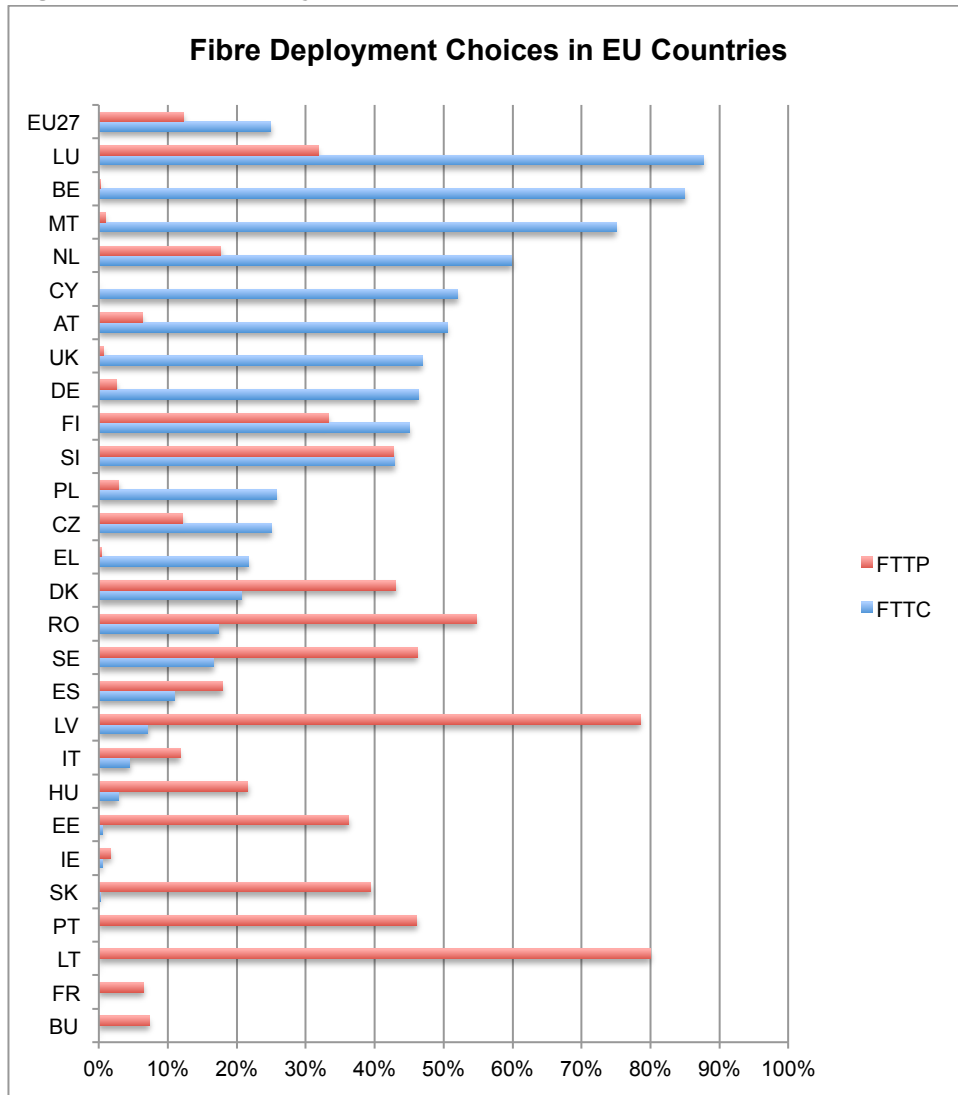
(Point Topic, 2012)

The regulatory authority responsible for the electronic communications sector in the UK is Ofcom, which has a statutory duty, under the Communications Act 2003, to promote the interests of consumers through competition, where appropriate[21]. However, in certain circumstances, as discussed in Section 2.4.2, the vertically integrated firm with a monopoly on the most upstream input has a strong incentive to leverage that dominance into downstream markets through anti-competitive practices, and in particular through discrimination or foreclosure. The regulator, therefore, has to impose restrictions on the firm's ability to behave in such a manner and/or change its incentives so that it no longer benefits from discrimination.

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[21] Ofcom's general duties are set out in Section 3.1 of the Communications Act 2003 as:
"It shall be the principal duty of OFCOM, in carrying out their functions—
(a) to further the interests of citizens in relation to communications matters; and
(b) to further the interests of consumers in relevant markets, where appropriate by promoting competition."

3.2 Discrimination in Telecoms and Broadband

The existing literature on discrimination in general was reviewed in Section 2.4. This section reviews two papers that have explored the problem of non-price discrimination specifically within the context of telecommunications markets: one in the USA and the other in the UK.

Writing in the context of Local Exchange Carriers (LECs) in the USA entering the long distance calls market, Sibley and Weisman (1998) developed a model of an integrated firm which has a regulated upstream input and which is entering a downstream market in which its competitors are also its customers in the access market. They ask: does the upstream monopolist have the incentive to raise the costs of its downstream rivals? They find that raising rivals' costs can have two opposing effects. First as rivals' costs increase, the upstream monopolist's downstream profits rise. However, there is also the opposite effect if a decrease in downstream output translates into lower demand for the input. This lowers profits from the access markets as long as the regulated input price exceeds marginal cost.

They model two organisation forms: in the first the monopolist enters downstream markets as a fully integrated firm. In the second, the monopolist enters through a "fully separate subsidiary" (FSS). Four restrictions apply to the FSS: (a) that information flows between parent and subsidiary are severely restricted; (b) the subsidiary acquires inputs from the parent company on the same observable terms as downstream competitors; (c) the manager of the subsidiary is compensated predominantly on the financial performance of the subsidiary; and (d) the subsidiary maintains completely separate financial, accounting and net income statements[22].

The analysis first finds that the regulated price of the input must be above the marginal cost of the input to deter the monopolist from raising rivals' costs. Secondly, if the integrated firm has a market share below 26% in the downstream market, it still benefits from lowering costs to downstream firms including its rivals' costs. Once the integrated firm's share rises above 26%, its incentives are to raise rivals' costs.

Thirdly, Sibley and Weisman find that because the (Cournot) quantity choice of the FSS is made to maximise its profits with no reference to the efficiency of the integrated provider, the monopolist is more inclined to raise rivals' costs in the short run than it would if it acted as a fully integrated firm. In other words, the 26% market share at which the integrated firm's incentive changes from reducing to increasing rivals' costs is lowered.

However, they also find that in a symmetric Cournot equilibrium with a sufficiently large number of firms, the monopolist subject to a FSS requirement will have

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[22] These restrictions are close to characteristics of functional separation as it applies in the case of BT in the UK. It is also close to Cave's (2006) 5th degree of separation.

incentives for pro-competitive behaviour. The intuition for this result is that if the upstream monopolist is entering the downstream market, it starts with a sufficiently small market share that it benefits more from stimulating overall market demand than it would do by foreclosing rivals.

In the UK, Cave, Corea and Crocioni (2006) discuss non-price discrimination particularly in the light of the Undertakings. Building on previous literature[23], Cave et al. draw on empirical evidence from the UK to show that tight upstream regulation is likely to strengthen the incentive to discriminate. They show evidence from BT's Regulatory Accounts and Annual Accounts that BT's profits from its downstream divisions and its overall profitability are increasing, "which supports the argument that BT might have an incentive to hamper downstream rivals". (Cave et al., 2006, p.399)

Cave et al. consider the relative merits of an integrated operator to indulge in both price and non-price discrimination. Like Salop and Scheffman (1983), they say that non-price discrimination is the more attractive option, as it does not come at the cost of foregoing short-term profits. Even if the probability of detection is the same, the firm will prefer non-price discrimination. However, as price discrimination is relatively easy to detect[24], especially when upstream prices are regulated, the firm will have an even greater preference for non-price discrimination. To be detectable, such behaviour needs to be observable and verifiable. Any inability to detect and verify such behaviour would reduce deterrence and therefore strengthen the incentive to engage in non-price discrimination.

3.3   BT's Incentive to Discriminate

This raises the question of whether BT in 2005 had an incentive to discriminate based on its upstream profitability. BT is required to publish annual Regulatory Financial Statements (RFS), which are the separated accounts of its upstream businesses where it has SMP. These accounts have been analysed by Frontier Economics (2013) in a report for Vodafone plc[25]. They find that in the year to March 2006, the first year of their analysis, BT earned a Return of Average Capital Employed (ROACE) of 18% for its regulated services. This rate was some 6.5 percentage points above the benchmark Weighted Average Cost of Capital (WACC). The relative efficiency of BT and its competitors' retail businesses at the time is unknown, but this ROACE would suggest that conditions two or three in Section 2.4.2 hold and that, rationally, BT's incentives to discriminate were lower than they would have been had BT made a lower ROACE relative to WACC. This does not mean that BT did not discriminate, as matters other than a rational analysis of profits may affect behaviour, or that entrants did not perceive discrimination.

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[23] In particular Economides (1998) and Beard, Kaserman and Mayo (2001).

[24] A similar point is made by Sand (2004) who says that it is inherently more difficult to regulate quality than price.

[25] Frontier Economics' report was not examining whether BT had an incentive to discriminate, but whether it was earning excess profits.

By contrast, Cave et al. (2006) found that BT was subject to strong regulatory constraints, with the regulated price of some key narrowband (telephone call) inputs[26] declining by as much as 50% over the period. They conclude that these strong constraints provided BT with an incentive to practise non-price discrimination.

Direct analysis of BT's RFS provides little extra clarity. Table 1 below shows the consolidated return on capital employed[27] (ROCE) for BT's relevant wholesale business reported in the RFS for each of 2004, 2005 and 2006[28].

Access	Allowed rate of return	ROCE	Division
2004	13.5%	15.6%	BT Network Business
2005	13.5%	12.5%	BT Wholesale Markets Consolidated
2006	11.5%	15.4%	BT Wholesale Markets Consolidated

Table 1: BT ROCE Wholesale Business

The "Allowed rate of return" is the regulated cost of capital that BT is permitted to earn in its regulated prices. As can be seen from the table, in 2004 and 2006 BT's ROCE exceeded the allowed rate, but was less than the allowed rate in 2005.

The equivalent calculation in its retail division is problematic as, according the RFS, BT had a negative capital employed in each of the three years and therefore the ROCE cannot be calculated.

In summary, therefore, it is difficult to establish definitively whether BT had an incentive to practise non-price discrimination against its rivals from an analysis of its profits. However, as shall be discussed later, whether there was such an incentive or not may have been less relevant in Ofcom's later decision making process than whether downstream rivals *perceived* there to have been a problem and adjusted their behaviour accordingly.

3.4 The Regulation of Dominant Firms in Telecoms

Article 102 TFEU and Section 18 of the Competition Act, discussed above, are relevant to all markets and not specific to any one sector of the economy. The sector-specific rules governing the electronic communications sector are discussed below.

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[26] Wholesale broadband inputs were not analysed in their paper.

[27] Calculated as $ROCE = \frac{Earnings\ before\ interest\ and\ taxation}{Total\ Assets - Current\ Liabilities}$.

[28] BT's financial year end is March 31st. Thus the 2006 RFS refers to the year ending 31/3/2006 rather than the calendar year 2006.

Under Section 7 of the Telecommunications Act 1984, which first opened the UK market to competition, both Mercury and BT were awarded Licences to provide services. Section 8(d) of the Act required any licensee not to behave in an unduly discriminatory manner: it required persons granted a licence:

> *"[N]ot to show undue preference to, or to exercise undue discrimination against, particular persons or persons of any class or description (including, in particular, persons in rural areas) as respects any service provided, connection made or permission given in pursuance of such conditions as are mentioned in the foregoing paragraphs (whether in respect of the charges or other terms or conditions applied or otherwise)."[29]*

Prior to 2003, the European telecommunications sector was governed by the Open Network Provisions (ONP) regulations, which set a blanket market share of 25% for declaring that a firm had market power, regardless of the specific market circumstances. In 1999 the European Commission launched a review of the ONP regulation (the 1999 Review), which resulted in a new set of five Directives, known as the Common Regulatory Framework (CRF). The European Council and Parliament passed four Directives in February and one in July 2002. Member States were required to transpose these into national law by July 24th 2003[30]. The five Directives were:

- The Framework Directive (2002/21/EC)
- The Access Directive (2002/19/EC)
- The Universal Service Directive (2002/22/EC)
- The Authorisation Directive (2002/20/EC)
- The Privacy and Electronic Communications Directive (2002/58/EC)

Whereas the ONP framework applied regulation to all activities of dominant firms, the CRF was designed to address market failure in relevant markets through a competition law-based approach. The main innovation of the CRF was to link regulation to the concepts and principles of competition law and therefore to take a more economics approach to regulating the sector. It was expected that as competition developed in the electronic communications markets, *ex ante* regulation could be phased out and replaced by *ex post* competition law[31].

The Framework Directive (FD) requires National Regulatory Authorities (NRAs) to conduct periodic market reviews for markets identified by the European Commission as "susceptible to *ex ante* regulation". In 2003 the Commission

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[29] Similar clauses can be found in the various Acts privatising other utilities such as electricity and gas.

[30] Very few countries achieved this deadline. Germany did not complete the process of transposition to national law until 1st July 2004. New Member states were required to transpose the CRF by the time of accession.

[31] Prof. Stephen Littlechild, who was instrumental in establishing the regulatory regime in the UK in the 1980s is referred to regulation as "holding the fort" until competition developed.

published a Recommendation setting out a list of 15 such markets. This list was subsequently revised in 2007 down to seven markets and, in 2014, was subject to a further revision and reduction to just five markets (European Commission, 2014).

A recommended market must fulfil three criteria (known as the "three criteria test"). It must:

1.   Have high and persistent barriers to entry;
2.   Not be tending towards effective competition; and
3.   Competition law alone cannot correct any competition problems.

In a market review, NRAs must define relevant geographic and product markets, determine whether any firm(s) has (have) Significant Market Power (SMP) in the market and, in the event of having SMP, apply obligations to the(se) firm(s) in those markets. Articles 14-16 FD set out the process of market definition and market analysis. Art. 14 defines Significant Market Power (SMP) as occurring when an undertaking "either individually or jointly with others, enjoys a position equivalent to dominance, that is to say a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers and ultimately consumers".

Article 16(2) FD sets out the market analysis procedure NRAs must follow. Obligations[32] may only be imposed on firms with SMP in the relevant market and may not be imposed if the NRA finds a relevant market to be effectively competitive. If a market is found to be competitive, the NRA must withdraw sector specific regulation and rely only on competition law.

In markets where one or more firms have SMP, the obligations that can be applied are consistent with those that competition authorities can apply *ex post,* however NRAs do not have the power to impose structural remedies such as requiring the break-up of a firm with SMP. The obligations NRAs may impose are set out in Articles 9-13 of the Access Directive (AD). These are:

•   Transparency, specifically the publication of a Reference Offer;
•   Non-Discrimination;
•   Accounting Separation;
•   Access to and use of specific network facilities; and
•   Price control and cost accounting.

Of particular importance to this thesis is the "Obligation of Non-Discrimination" (Article 10 AD), which consists of two paragraphs:

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[32] Throughout this thesis, the word "obligations" is used in reference to *ex ante* findings of SMP and "remedies" in relation to *ex post*. This is consistent with the fact that under *ex ante* regulation the NRA is seeking to prevent a behaviour from taking place rather than correct a behaviour that has taken place.

> *"1. A national regulatory authority may, in accordance with the provisions of Article 8, impose obligations of non-discrimination, in relation to interconnection and/or access.*
>
> *"2. Obligations of non-discrimination shall ensure, in particular, that the operator applies equivalent conditions in equivalent circumstances to other undertakings providing equivalent services, and provides services and information to others under the same conditions and of the same quality as it provides for its own services, or those of its subsidiaries or partners."*

It should be noted that a firm that is found to have SMP under the sector specific regulations remains subject to competition law provisions regarding the behaviour of a dominant firm. Indeed, even a firm without SMP could, in theory, be found to be dominant under competition law. In general, the findings of a market review under *ex ante* regulation are not binding on competition authorities investigating a potential breach of the competition law. Thus, the competition authority could define a different relevant market and find a different firm dominant in that market. Perhaps surprisingly, complying with regulatory obligations are not a sufficient defence against a complaint of anticompetitive action if those obligations are themselves equivalent to an abuse of market power.

In *Deutsche Telekom*[33] the European Commission found that, despite the fact that Deutsche Telekom was charging the regulated price for local loop access it was still in breach of (then) Article 82 as that regulated price resulted in a margin squeeze. It was found that Deutsche Telekom had the flexibility under the price cap regime in place to set the margin in a manner that did not constitute a margin squeeze.

The CRF, was transposed into UK law by the Communications Act 2003, which entered into force on July 23rd 2003. The non-discrimination obligation, set out in Section 87(6)(a) of the Act, allows the regulator to impose *"a condition requiring the dominant provider not to discriminate unduly against particular persons, or against a particular description of persons, in relation to matters connected with network access to the relevant network or with the availability of the relevant facilities."*

In neither the EU Directive nor the UK law is discrimination banned outright. The AD requires only that the operator "applies equivalent conditions in equivalent circumstances" whilst UK law proscribes the dominant provider from "unduly discriminating".

Oftel (2002, Sections 3.4-3.11) gave guidance as to its interpretation of non-discrimination. Perhaps the most significant paragraph of which is 3.8:

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[33] Case COMP/C-1/37.451, 37.578, 37.579 — *Deutsche Telekom.*

> *"'Non-discrimination' does not necessarily mean that there should be no differences in treatment between undertakings, rather that any differences should be objectively justifiable, for example by:*
> *a) differences in underlying costs, or*
> *b) no material adverse effect of competition."*

In Section 3.11 Oftel says that it would find differences in underlying costs to be a valid justification for making different products available on different terms to different parties.

National telecommunications network were designed and built to carry a signal end-to-end on the same network, not for interconnection with other networks that either originate or terminate the call. The very act of interconnection creates a cost (installing and managing the interconnect) that is not incurred by a call being carried only on a single network. Thus, in theory, the incumbent operator could charge a cost for an interconnected call which is greater than the cost of that portion of a call on its own network without being in breach of a non-discrimination obligation. This higher price may send economically efficient messages to interconnecting parties as they would be expected to pay the cost of interconnected traffic rather than on-net traffic.

On 25th November 2009, the European Parliament and Council adopted a new Directive amending the CRF[34]. This amending Directive introduced a new article, Article 13a, to the Access Directive (AD)[35] empowering NRAs to "impose an obligation on vertically integrated undertakings to place activities related to the wholesale provision of relevant access products in an independently operating business entity": this is known as "functional separation".

The new article 13a sets out the conditions under which such a requirement can be imposed and the conditions which the NRA must fulfil before it can impose functional separation. The NRA may only impose the obligation when it is clear that other remedies "have failed to achieve effective competition and that there are important and persisting competition problems and/or market failures identified in relation to the wholesale provision of certain access product markets".

However, before the NRA can impose functional separation it must submit a proposal to the European Commission (EC) setting out: its evidence that other remedies have failed; a reasoned assessment that infrastructure competition is unlikely to develop; a regulatory impact analysis; and a demonstration that functional separation is the most efficient means to correct market failures.

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[34] DIRECTIVE 2009/140/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2009 amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities, and 2002/20/EC on the authorisation of electronic communications networks and services.

[35] Directive 2002/19/EC.

The new article also prescribes the contents of any draft measure put forward by the NRA, which must specify: the legal status of the separate business entity; the assets of the entity; its governance arrangements; rules for ensuring compliance; rules for ensuring transparency; and a monitoring programme.

Article 13a does not prescribe the exact form of separation, allowing the NRA to specify the legal status of the separate business entity (Sub section 3(a)). Therefore, despite naming the form of separation as functional, it is possible that the separate entity could be a new subsidiary of the SMP operator, implying legal separation. (See Section 2.5 for a discussion on the forms of separation.)

The purpose and expected benefits of functional separation are set out in Recital 61 of the amending Directive. The Directive states that "functional separation has the capacity to improve competition in several relevant markets by significantly reducing the incentive for discrimination and by making it easier to verify and enforce compliance with non-discrimination obligations". The Council and Parliament are clearly aware of arguments that functional separation could damage investment incentives. Recital 61 also states that "it is very important to ensure that its imposition preserves the incentives of the concerned undertaking to invest in its network and that it does not entail any potential negative effects on consumer welfare".

Finally, Recital 62 says that "the implementation of functional separation should not prevent appropriate coordination mechanisms between the different separate business entities in order to ensure that the economic and management supervision rights of the parent company are protected".

The amending Directive also sets out a new Article 13b AD covering voluntary separation by a vertically integrated undertaking. This requires undertakings with SMP, which intend to transfer ownership of the local access network or to establish a separate business entity to provide all retail providers, to notify their NRA.

The new Articles 13a and 13b AD therefore set out the conditions for mandatory and voluntary separation beyond accounting separation.

In November 2013, the European Commission published a Recommendation on non-discrimination and cost accounting. The Recommendation stated:

> *"One of the main obstacles to the development of a true level playing field for access seekers to electronic communication networks is the preferential treatment of the downstream businesses, for example the retail arm, of a vertically integrated operator with significant market power (SMP operator) through price and non-price discrimination."* (European Commission, 2013A, para. 12)

The standard non-discrimination obligation available to NRAs under Article 10 of the Access Directive[36] ("equivalent conditions in equivalent circumstances") has, according to the Commission, been inconsistently applied. It has also proved to be insufficient to ensure that the SMP operator provides access in a manner that allows entrants to compete on equal terms. For example, entrants and incumbents may use different wholesale inputs and processes that put entrants at a competitive disadvantage.

The Commission's Recommendation suggests that, in certain circumstances, NRA should impose an obligation of Equivalence of Inputs (EoI):

> *"[T]he surest way to achieve effective protection from discrimination as access seekers will be able to compete with the downstream business of the vertically integrated SMP operator using exactly the same set of regulated wholesale products, at the same prices and using the same transactional processes. In addition, and contrary to an Equivalence of Output (EoO)[37] concept, EoI is better equipped to deliver transparency and address the problem of information asymmetries."* (European Commission, 2013A, para. 13)

EoI is a form of non-discrimination specifically designed for an *ex ante* regulatory environment. It will be discussed in much greater detail in Chapter 4 of this thesis.

The Recommendation does not propose EoI should be applied to all products, rather only where it is proportionate to do so as EoI is expensive to implement. The Commission recommends that EoI should be applied on Next Generation Access (NGA) and at the deepest level of the network. Where EoI is applied, the Commission also recommends that a price control can be removed provided that a proper margin squeeze test is present.

3.5   Case Study: Telecom Poland

Discrimination in telecoms market is not merely a theoretical possibility but has also been found to have occurred in practice, as a recent case in the Polish telecoms sector, described below, demonstrates.

The Polish regulator, UKE (Urząd Komunikacji Elektronicznej) found that discrimination problems exist in the market and, in 2008, commissioned a report, by a consortium led by the consultancy firm KPMG, into the market situation in Poland[38]. That report found that "there exists a persistent barrier to the

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[36] DIRECTIVE 2002/19/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive) as amended by Directive 2009/140/EC.

[37] EoO is equivalent to the standard non-discrimination remedy of "equivalent conditions in equivalent circumstances".

[38] The full version of the report is available only in Polish (KPMG 2008). The references are to a brief English summary available at

development of the market in the form of Telekomunikacja Polska's (TP)[39] anti-competition approach, which manifests itself by obstructive actions as far as co-operation with alternative operators is concerned." It found that the existing regulatory measures had not eliminated barriers to market development and that there was a lack of perspective among alternative operators that these barriers will be removed.

The consortium recommended that UKE impose functional separation on TP and that the Polish regulatory framework be amended to allow the imposition of this remedy. As yet this obligation has not been imposed.

In June 2011 the European Commission adopted a decision under Article 102 TEFU against TP[40]. The Commission found three relevant product markets that existed in a vertical relationship through a single, national, geographic market.

1.   The market for wholesale physical network infrastructure access at a fixed location (the wholesale market for Local Loop Unbundling [LLU]);
2.   The market for wholesale broadband access (Bitstream Access [BSA]); and
3.   The retail mass market for broadband access at a fixed location, which excluded mobile broadband.

TP was the only provider on a nationwide basis of both LLU and BSA and therefore was a pure monopolist in both markets. In the period covered by the decision, TP also held a retail market share of between 46 – 57% of revenue and 40 – 58% of retail access lines.

The Commission found that TP had abused its dominant position in the markets for Local Loop Unbundling and Bitstream Access and specifically that TP was

•   Proposing unreasonable conditions governing Alternative Operators' (AO) access to wholesale broadband products. The conditions imposed were worse than the ones guaranteed by the Reference Offers and the AOs had very little bargaining power so were forced either to abandon negotiations, accept TP's proposal or refer to the regulator.
•   Delaying the negotiation process. TP adopted several tactics to delay even starting the negotiation process. In an extreme example, one AO received a draft contract after 226 days instead of the three days required by regulation.
•   Limiting access to its network. TP rejected a number of orders from AOs for both BSA and LLU on spurious formal and technical grounds.

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http://www.en.uke.gov.pl/ukeen/index.jsp?place=Lead02&news_cat_id=61&news_id=731&layout=1&page=text Downloaded 9/2/2015 .

[39] TP has subsequently been rebranded as Orange.

[40] The full case is available only in Polish. Much of the description included here is taken from Kamiński, Rògozińska and Sasinowska (2011) and from European Commission (2011).

- Limiting access to subscriber lines. Access to lines was limited also by rejecting orders placed by AOs on formal and technical grounds.
- Refusing to provide. TP did not provide alternative operators with the reliable information about their network that they needed to make decisions about access to TP's wholesale products or provided incomplete information.

The abuse was found to have started in August 2005 and continued until at least October 2009.

The Commission concluded that TP's abusive conduct was capable of restricting competition in the retail market and was likely to reduce the rate of entry and expansion of competitors. It further concluded that the differences in treatment were not objectively justifiable and therefore were discriminatory. TP was fined €127.6 million and ordered to bring an immediate end to the infringement and to refrain from practices that would have the same or similar object or effect as described in the decision.

The TP case is one of non-price discrimination, with TP providing inferior quality to its rivals than it provided to its own downstream retail division, but at the same price. To remain competitive with TP, its rivals would need to charge retail customers a lower price to make up for the lower quality. As they are paying the same price for the wholesale input, being forced to charge a lower price has a similar affect to a margin squeeze. Economides (1998) suggests that inferior quality can be considered an extra cost borne by the rival. Whereas the monopolist earns a profit

$$\Pi_1^D = (p - s - w)q_1 - F^D$$

The rival earns a profit

$$\Pi \equiv \Pi_i^D = (p - s - w - r)q_i - F^D$$

Such that

$$\Pi_i^D < \Pi_1^D$$

Where:
p = retail price
s = wholesale cost of inputs other than access
w = wholesale cost of access
r = cost of inferior quality (r>0)
q = quantity
 F = Fixed costs.

The subscripts 1 and i denote the upstream, integrated monopolist and downstream rival respectively and the superscript D refers to the downstream market (Economides, 1998).

By providing inferior quality, therefore, TP raises its rivals' cost by r. Referring back to Figure 3, this is akin to TP raising the costs of the marginal producers from c_m to c'_m, with the result that prices in the market are raised and output reduced. This outcome is exactly what the Commission found to be the case. In January 2010, broadband penetration in Poland was 13.5%, one of the lowest in the EU and significantly below the average of 24.9%. Prices in 2009 were the second highest in the OECD.

The behaviours described in Section 2.3, therefore, are not merely theoretical, but have been found to have been effected in practice by an upstream monopolist with the effect of harming both competition and consumers.

3.6   Conclusion from Chapter 3

The structure of the telecommunications sector, and the natural monopoly characteristics of the local loop, mean that the sector is prone to the vertically integrated incumbent discriminating against competitors in downstream markets. The European Union has ensured that NRAs have the regulatory tools to address discrimination but, even so, at least one operator has been found to have behaved anticompetitively by sabotaging its downstream rivals. The Commission has recommended that NRAs take advantage of a form of non-discrimination obligation designed specifically for *ex ante* regulation: Equivalence of Input. EoI was first developed as a concept in the UK, as will be discussed in detail in the next chapter.

4 From "No Undue Discrimination" to "Equivalence of Input"

This section sets a historical record of the regulatory changes imposed by Ofcom in the UK broadband market in 2004 and 2005. It also briefly describes similar regulatory changes adopted in other countries and in other utility markets.

4.1 The UK Telecommunications Sector Before 2002

Until 1984, fixed line telecommunications in the UK, in common with other utility sectors, was provided by a state-owned monopoly. In all EU countries, except Sweden, the monopoly was a legally-mandated monopoly. This consensus was first broken in the UK with the part-privatisation of BT (then British Telecom) and the introduction of Mercury Communications as a protected competitor in some markets, primarily international and long distance calls. At the time of privatisation BT was kept as a vertically integrated firm and so Mercury had to negotiate access to BT's network for interconnection on commercial terms. Unsurprisingly these negotiations failed and the regulator, Oftel, therefore had to adjudicate and set access charges on a cost-oriented basis designed to reflect the competitive level (Newberry, 2001, p. 192-3)[41].

The duopoly lasted until 1991 when various forms of licensed resellers were allowed into the market and cable companies, previously restricted to offering TV services, were permitted to offer local telephone access over their cable networks. By 1995 there were over 150 operators licensed to compete with BT, mostly as resellers and with a strong bias toward international calls.

The European Union Directives that comprise the CRF were transposed into UK law via the Communications Act 2003. The Act also established a new regulator for the communications industry, the Office of Communications (Ofcom), formed by the merger of five individual regulators:

• The Broadcasting Standards Commission,
• The Independent Television Commission,
• The Office of Telecommunications (Oftel),
• The Radio Authority, and
• The Radiocommunications Agency.

4.2 The Ofcom Telecoms Strategic Review

4.2.1 The Consultation Phase

One of Ofcom's first tasks was to launch a Strategic Review of Telecommunications (known as the Telecoms Strategic Review or TSR). This

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[41] Newberry (2001) contrasts the situation with regard to BT with both Gas, where British Gas was left vertically integrated and free to foreclose its rivals, and electricity which was vertically separated from privatisation.

was because, despite progressive waves of liberalisation since 1984, and new regulation designed to address market problems using competition law methods and remedies, BT remained the dominant firm in most markets in 2003. Prior to the establishment of Ofcom, its predecessor, Oftel, and the UK government had been subject to extensive lobbying by various industry players to conduct such a review[42].

The TSR was launched in April 2004 with a first phase consultation document. Ofcom described the purpose of the review as to:

> *"[A]ssess the options for enhancing value and choice in the UK telecommunications sector. It will have a particular focus on assessing the prospects for maintaining and developing effective competition in the UK telecoms markets, while also considering investment and innovation."* (Ofcom, 2004, para. 3.2)

Ofcom's analysis of the sector examined the level of competition at the time and how competition was likely to develop together with an analysis of technology trends. Stakeholders were asked "five fundamental questions" and 16 more detailed questions. The five fundamental questions were:

> *"Question 1: In relation to the interests of citizen-consumers, what are the key attributes of a well-functioning telecoms market?*
> *Question 2: Where can effective and sustainable competition be achieved in the UK telecoms market?*
> *Question 3: Is there scope for a significant reduction in regulation, or is the market power of incumbents too entrenched?*
> *Question 4: How can Ofcom incentivise efficient and timely investment in next generation networks?*
> *Question 5: At varying times since 1984, the case has been made for structural or operational separation of BT, or the delivery of full functional equivalence. Are these still relevant questions?"* (Ofcom, 2004 para. 1.2)

Responses were received from over 100 interested parties and were wide-ranging. However, a central theme to emerge was the problem of discrimination and the perceived ineffectiveness of the legal/regulatory regime to prevent such behaviour. Some operators went further and argued that both the AD and the UK law allowed dominant operators to discriminate by not providing equivalent products in equivalent circumstances.

Cable & Wireless (C&W) considered the "no undue discrimination" remedy, as defined in the Communications Act and applied by Oftel, to be inadequate. In its response to the TSR, which appeared to have a strong influence on Ofcom's later analysis, it stated:

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[42] The author had worked for Cable & Wireless to prepare a report on the benefits of separation of BT. However, he was not involved in drafting C&W's response to the TSR.

"By far the biggest issue for this review is the problem of discrimination as regulating to prevent discrimination remains the key unsolved problem of regulation. Although there are existing regulatory rules and structures to deal with the problem of discrimination, in practice they have been ineffective in preventing BT from favouring its own operations.

"The examples of such discrimination are endless. In the world of broadband, BT was allowed to create an LLU product which was prohibitively expensive, not industrialised and not fit-for-purpose, which meant that it was entirely unsuitable for mass-market take-up. The result is that there is currently virtually no competition in broadband based on LLU. In the world of narrowband voice, there is a similar story to tell. The basic monopoly access network building blocks to narrowband competition, such as call origination, carrier pre-selection and wholesale line rental have all been made available to BT's competitors on sub-standard terms, such that the cost base of competitors, and the maximum functionality they can offer to customers, are compromised. Again, the result is that BT has been permitted to retain an artificially high market share in narrowband voice to the detriment of innovation and of end-users." (Cable & Wireless, 2004)

Energis (which has subsequently been acquired by Cable & Wireless, which has itself subsequently been acquired by Vodafone) also discussed the problem of undue discrimination, and also appears to have been influential on Ofcom. It stated:

"Oftel's approach to equivalence (in common with many regulators in telecommunications around the world) took as its starting point a formal requirement for equal treatment (or non-discrimination) and then engaged in a series of compromises based on equivalence of outcome to produce the detail of regulatory decisions.

"The essence of this approach can be seen in the debate over the use of the term 'undue' discrimination. This approach embedded the concept of 'due' discrimination in the regulatory regime, allowing differences between the systems that BT used to supply itself, and competitors, where there were 'objectively justifiable' differences. The problem with that approach is that it assumed that Oftel would be effectively empowered to distinguish between 'due' and 'undue' discrimination. While in many cases this approach seems to have worked, in other markets, that hasn't been the case." (Energis, 2004)

The essence of these responses was that preventing discrimination was not enough when discrimination allows justifiably different treatment by the dominant firm of its own downstream business and that of its competitors. Such discrimination could take both price and non-price forms, though non-price discrimination was both harder to detect and easier to implement.

Ofcom agreed with the statement by C&W and, in the Phase 2 consultation document, it said "We believe that similar stories could be told about carrier pre-selection, wholesale line rental, partial private circuits and indirect access in their early days" (Ofcom, 2004B, para. 6.3).

Referring back to the legal definitions of discrimination, BT could well argue that differences between internal and external cost and terms were justified and that therefore they were not discriminating under the definition of "undue discrimination".

However, such a defence was unnecessary as no discrimination cases were successfully brought against BT: indeed, Ofcom did not find explicit evidence of discrimination during its review. What became clear, however, was that competing Communications Providers (CPs) lacked confidence in a system that allowed BT to "duly discriminate" as evidenced by the paragraphs from the responses of Cable & Wireless and Energis, quoted above. The expectation of different treatment was enough to change the behaviour of downstream competitors.

Unsurprisingly, BT did not mention the concerns of C&W and Energis in its response to the Phase 1 consultation. Also unsurprisingly, it argued against structural separation, as mentioned in the fifth of Ofcom's five fundamental questions, but did accept that there was scope for greater equivalence of treatment by BT Wholesale towards both BT Retail and rival downstream firms (Ofcom, 2004B, para. 3.29).

On 18th November 2004, Ofcom issued its Phase 2 consultation document (Ofcom, 2004B). This reviewed the comments received from the first phase and put forward specific proposals for future regulation of the electronic communications market.

Central to Ofcom's analysis in Phase 2 was the concept of "enduring economic bottlenecks" which it described as those areas of the network where "effective, infrastructure based competition is unlikely to emerge in the medium term" (Ofcom, 2004B, para 1.17). Ofcom considered that Cable & Wireless's example of LLU provided a good example. LLU allows competitive operators to rent the copper local loop, which runs between the local exchange and the customer premises. The LLU customer needs to install its own equipment in the local exchange to allow broadband signals to be sent over the local loop. It can then sell that service to consumers. BT did not use LLU as a wholesale input to provide broadband access at the time of the TSR, so BT's retail division was using a different wholesale product from its competitors.

In possibly the most damning paragraph in the Phase 2 consultation, Ofcom said that competing operators who rely on BT for access "*have experienced twenty years of:*

- *Slow product development;*
- *Inferior quality wholesale products;*
- *Poor transactional process; and*
- *A general lack of transparency."* (Ofcom, 2004B, para 1.19)

Ofcom concluded that the non-discrimination remedy by itself had proved inadequate to address the competition problems caused by economic bottlenecks and that a stronger remedy was needed. In a paragraph that reflected Energis's comments, it partially laid the blame at the door of its predecessor, Oftel:

> *"Oftel's approach might be characterised as accepting certain differences of outcome which arise from the existence of asymmetrical inputs for BT's downstream businesses and those of third parties, provided these were not material, or deliberately or perversely created by BT to impede competition. Oftel worked to ensure that wholesale products specifically designed by BT under regulatory pressure were as close to being fit-for-purpose as possible. But clearly this approach has not resolved the continuing problems of lack of equality of access in a number of areas. Firstly, BT faces weak incentives to comply, and as a result the achievement of fit-for-purpose products which BT itself has no interest in using or selling has required a high degree of regulatory intervention. Secondly, the process permits differences between the treatment of BT's wholesale customers and its own retail activities which, while relatively insignificant in isolation, constitute significant disadvantage when taken in combination."* (Ofcom, 2004B, para. 6.11)

In the last sentence of this quotation, Ofcom discusses what has been referred to as "cumulative materiality". This is the idea that it is possible for there to be many minor differences between an internal and an external wholesale product which, when each difference is taken alone, appears relatively unimportant but which when they have a cumulative impact can result in a significant disadvantage for the external customer.

4.2.2 Ofcom's Proposals and The Undertakings

Ofcom's principal proposal arising from the TSR was to strengthen the non-discrimination remedy by requiring what it termed "real equality of access" which would prevent BT having justifiable reasons for providing different services internally and externally. This would require "equivalence" at the product level and clear behavioural changes by BT.

At the product level, Ofcom stated that equality of access implies BT's wholesale customers should have access to:

> *"The same or a similar set of regulated wholesale products as BT's own retail activities;*
> *At the same prices as BT's own retail activities; and*

Using the same or similar transactional processes as BT's own retail activities." (Ofcom, 2004B, para 1.36)

Ofcom termed these characteristics "equivalence of input". It also stated that it was important that there is equivalence throughout the product development process and product life cycle. It implied that BT's wholesale customers should have the same ability as BT's retail activities to introduce changes or have problems addressed.

The final stage of the TSR was the issuing by Ofcom of a "Statement" including a set of Undertakings by BT in lieu of a reference under the Enterprise Act 2002 (Ofcom, 2005, the "Undertakings"). The Undertakings had two main themes: a specifically *ex ante* form of non-discrimination obligations, "Equivalence of Inputs" (EoI), and a reorganisation of BT placing those access products over which it had SMP into a separate Access Services division. The details for these two themes are discussed below.

4.2.3   Equivalence of Input

Paragraph 2 (Definitions and Interpretation) of Annex A of the Undertakings sets out what is meant by Equivalence of Input:

> *"'Equivalence of Inputs' or 'EoI' means that BT provides, in respect of a particular product or service, the same product or service to all Communications Providers (including BT) on the same timescales, terms and conditions (including price and service levels) by means of the same systems and processes, and includes the provision to all Communications Providers (including BT) of the same Commercial Information about such products, services, systems and processes. In particular, it includes the use by BT of such systems and processes in the same way as other Communications Providers and with the same degree of reliability and performance as experienced by other Communications Providers."*
> (Ofcom, 2005, p. 61)

In a helpful qualification, the Undertakings state the "Same means exactly the same" However, there are some variations allowed in the definition that may mean the same does not mean exactly the same. These are listed in the Undertakings as:

> *"a)   trivial differences;*
> *"b)   such other differences as may be agreed by Ofcom in writing;*
> *"c)   differences relating to the following:*
> > *i)   credit vetting procedures;*
> > *ii)   payment procedures;*
> > *iii)   matters of national and crime-related security, physical security, security required to protect the operational integrity of the network and such other security requirements as agreed between BT and Ofcom from time to time;*

The list of products to which EoI was applied is set out in paragraph 3.1 of the Undertakings. These are:

a)   Wholesale Analogue Line Rental; }
b)   Wholesale ISDN2 Line Rental;   } WLR
c)   Wholesale ISDN30 Line Rental;   }
d)   Wholesale Extension Service (WES);
e)   Shared Metallic Path Facility (SMPF);
f)   Metallic Path Facility (MPF);
g)   IPStream; and
h)   Backhaul Extension Service (BES).

Note MPF and SMPF are specific forms of LLU.

Paragraph 3.1 also commits BT to providing certain, at the time, future services on an EoI basis. These are listed as:

a)   Wholesale Extension Service Access Product;
b)   Wholesale Extension Service Backhaul Product;
c)   Wholesale End-to-End Ethernet Service;
d)   IP based Bitstream Network Access products that are the successors to IPStream or DataStream; and
e)   A successor product to Wholesale Line Rental if:
   i)   such a product is provided using BT's Next Generation Network (NGN), based on Multi-Service Access Node (MSAN) access; and
   ii)   BT is determined by Ofcom to have SMP in a Network Access market or markets which includes that product.

Ofcom also introduced the concept of "equivalence of outcome" which was more akin to non-discrimination and was applied to products which at the time were expected to become redundant as they were overtaken by new services such as those listed above.

EoI was and remains a radical change from the "no undue discrimination" requirement and this is central to an understanding of the Undertakings and their impact on the UK telecommunications market.

BT, or indeed any other incumbent firm, could legitimately argue that its network was built for use by a single integrated firm and was not designed for access by other networks. It was designed to carry calls from the calling party to the receiving party (end-to-end calling) and not to pick up calls or deliver calls to other networks. Therefore, BT could argue that it faced lower costs to deliver a call end-to-end on its own network than to carry calls to or from an interconnected network. Likewise it could argue that it could provide different order processing systems internally and externally.

Therefore, under the definition of non-discrimination adopted by Ofcom, its treatment of internal and external customers differently was objectively justifiable and therefore not unduly discriminatory. Nevertheless, industry participants and Ofcom determined that the competition policy principle of non-discrimination was not sufficient to stimulate effective and sustainable competition downstream of the economic bottleneck and so a stronger, specifically *ex ante* remedy was required to overcome the incentive to discriminate. As will be discussed in Section 4.3 below, some have argued that not allowing BT to take advantage of its vertical integration would lead to a loss of efficiency.

Whereas under the old "no undue discrimination" obligation BT could use a different set of inputs from those sold to competitors, EoI required BT to use the same set of inputs. BT could not provide its own downstream business with broadband access based on an internal product specification and MPF or SMPF to its rivals. Instead BT has to use SMPF or MPF internally and provide those products to other CPs under the same terms and conditions and so forth. The word "equivalence" may be a misnomer, as BT was required to use the same products as its rivals, and thus "Equality of Inputs" may be a more accurate description.

BT is also expected to respond to requests for new services from wholesale customers using the same process, i.e. it should not distinguish between a request from BT Retail and one from external customers.

There has been no legal testing of equivalence but it would seem unlikely from the unequivocal wording of the Undertakings that BT could claim external customers were not in an "analogous situation" to their internal customers.

Equivalence of Input can therefore be regarded as a specifically *ex ante* approach to deter discrimination, whereas the "no undue discrimination" obligation was an *ex post* remedy but applied *ex ante*.

4.2.4 Functional Separation

The second major obligation on BT in the Undertakings was what has become known as "functional separation", although the term itself was not used at all in the document. Under Section 5 of the Undertakings, BT was obliged to create "Access Services' (AS), the function of which was to provide "SMP Products which are predominantly using the Physical Layer and/or Transmission Layer of the BT's Access Network and/or the Physical Layer and/or Transmission Layer of

BT's Backhaul Network" (Ofcom, 2005, Section 5.3). These are the products in which there was an enduring economic bottleneck and in which competition was not expected to emerge in the medium term.

The Undertakings set out various other obligations on Access Services, including:

- It was to be a separate division with BT. Note that AS is not a separate subsidiary company. Customers of AS therefore contract with BT plc and not with AS.
- AS was to have its own Chief Executive Officer (CEO) who would report "solely and directly" (5.25) to the BT Group plc CEO, but not be a member of the BT Group Operating Committee.
- The Management Board of AS was to manage the division "to secure compliance with those sections of these Undertakings applicable to AS" (5.27).
- The CEO was to have delegated authority from the BT Group plc Board to authorise capital expenditure of up £75 million per annum.
- The AS management team was to move to separate accommodation from the rest of BT.
- Remuneration of BT employees working of AS was to "reflect solely the objective of AS. AS will operate to a Scorecard which reflects its responsibilities to deliver Equivalence of Inputs and fair access to its products" (5.36).
- No employee of BT who does not work for AS should be allowed access to Commercial Information of AS. Likewise, BT employees working for AS were not allowed to divulge Commercial Information to other BT employees (5.38 and 5.39).
- BT was required to develop a separate brand name for AS that did not incorporate BT or British Telecom. The brand used for AS was Openreach. The branding could include the words "a BT Group business" and the BT logo (5.48). An example of the Openreach brand in shown in Figure 10, illustrating how BT was allowed to use the various devices discussed above.

Figure 10: An Openreach branded van

4.3   The Debate about Functional Separation

The functional separation of BT was perhaps the more controversial of the two primary measures included in the Undertakings. In the wake of their publication there was a plethora of articles and consultancy reports published stating the case for and, mainly, against separation.

Tropina, Whalley and Curwen provide a good overview of the debate within the European Union and the state of play of functional separation at the time of the article. Placing functional separation in a wider context, they point out that "problems arise when companies in the competitive part of an industry require access to the non-competitive part to deliver their own services to their customers" (Tropina et al., 2010, p. 232). Whilst competition based on separate infrastructure may be preferable, depending on entry costs and economies of scale, such competition may take time to emerge. By contrast, service competition can emerge relatively quickly but it relies on access to the incumbent's infrastructure; this would be encouraged by functional separation. However, they point out that some authors have argued that functional separation would reduce the incentives for new entrants to invest in infrastructure leading to a delay in the development of infrastructure competition.

Functional separation is in part motivated by a desire to offset the advantages an incumbent gains from vertical integration, which "facilitates the efficient allocation and coordination of resources between different parts of the incumbent" (Tropina et al., 2010, p. 232). They conclude their discussion on the forms and challenges of separation by saying: "Regardless of the form [of separation] that is adopted, the motive is the same, namely, to resolve the tensions that exist within industries characterised by containing both competitive and non-competitive elements" (Tropina et al., 2010, p. 233).

In a paper reviewing separation in telecommunications markets, de Bijl (2005) summarises the arguments for and against full structural separation. The key argument in favour of separation is that it eliminates the incumbent's incentives to raise rivals' costs by reducing quality or increasing the cost of access. Other arguments in favour include removing the scope for leverage of market power into related markets and allowing the coordination of investments between all service providers and the network operator, rather than only within the integrated firm. The arguments against separation include the cost of separating the incumbent and deciding where to 'draw the line' between the separated entities. A further argument against separation is that it eliminates the coordination benefits and the economies of scale and scope that come from vertical integration.

Critics of separation claim that it would harm investment incentives based on two related arguments. First, separation will damage information flow between consumers, the downstream and upstream entities making it harder to coordinate investment decisions. Vertical integration would internalise information flows and so be more efficient than separation (Cave, 2008; Ergas, 2007). Secondly,

separation introduces a danger that downstream firms will attempt to earn quasi-rents by playing strategic games after the upstream firm has made a relationship-specific investment (the "hold-up problem") that will reduce investment (Ergas, 2007; Crandall, Eisenach and Litan, 2009[43]).

4.3.1   Information Flow

Crandall et al. argue that telecoms networks display a very high degree of asset specificity between the upstream access network and downstream retail operations and that economic efficiency gains will be greatest in the presence of such asset specificity. It is for this reason, they argue, that "market forces" have led telecoms companies to become vertically integrated. Telecoms networks require high levels of investment and display high levels of complexity and uncertainty. "Under these circumstances, the costs of coordinating upstream and downstream activities through contracts are likely to be high, and the case for vertical integration especially strong" (Crandall et al., 2009, p.505). They conclude:

> "In sum, economic theory, supported by empirical evidence from a variety of industries, suggests that vertical separation in the telecoms sector risks creating substantial problems for innovation and investment, especially when major new infrastructure investments are involved." (Crandall et al., 2009, p.509)

Waverman and Dasgupta (2007)[44] also argue that functional separation will create an environment in which entrants and incumbents alike will have lower incentives to invest. As a result, functional separation could be a technological "cul-de-sac" in which Europe is left with competition at the retail level, but within technological constraints imposed mainly by the existing copper-wire infrastructure.

Their argument is that a functionally separated firm considering investment in Next Generation Access (NGA) will be required to offer access at cost-reflective prices which, in their view, do not reflect all the true economic costs that an incumbent firm faces. Few incumbents would find such an investment attractive if they have to share the returns on that investment with their downstream competitors.

Entrants too will have less incentive to invest as they will always have the option to buy the same infrastructure as the incumbent. They would not make investments in their own networks unless the pay-offs were very high.

Although presented as such, Waverman and Dasgupta's concerns are not in fact specific to functional separation, but are pertinent to any form of price regulation in any market structure where there is dominance in the upstream input. In the

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[43] Crandall et al. acknowledge the financial support of Verizon Communications for their paper. Verizon, a US company, was strongly opposed to any form of separation.

[44] Although apparently written without the support of any interested party, Waverman has in previous papers commented on issues with the financial support of incumbent telecoms operators.

absence of any effective competition in upstream markets and/or the likely emergence of such competition, the dominant upstream firm is always likely to be subject to price regulation to prevent it earning monopoly rents and to prevent it price discriminating against its downstream competitors.

Cave (2008) suggests that, in a separated environment, the upstream entity will have no direct contact with end-users and so information about demand is only available at one remove. He also claims that in a functionally separated environment there is a systemic problem. Properly to mimic a structurally separated environment, there should be no more contact between the upstream and downstream arms than there would be between the upstream arm and an external customer.

This last argument concerning information flows seems particularly misplaced. There are many examples of industries where the value chain is not vertically integrated within a single firm but where information about demand flows between consumers and the upstream manufacturing firms via intermediate suppliers and retailers. Separation does not of itself necessarily lead to any disruption in the information flow between vertically related, but structurally separated, firms.

4.3.2 The "Hold-Up" Problem

A second problem identified by critics was the "hold-up" problem. Writing in the context of the Australian proposal for a functionally separate high-speed broadband network, Ergas (2007) reviews four externalities which arise from separation, one of which is investment[45]. He argues that an investment by an upstream electronic communications firm is "relationship-specific", that is to say that the investment is tailored to meet the needs of another party and cannot be used by a third party. This places the investor at a disadvantage, as the party for whom the investment is made can behave opportunistically based on the fact that the investor has limited possibilities to utilise the investment for alternative purposes.

Vertical integration between the parties would internalise the gains to be made from the investment and so remove the incentive for opportunism between the parties.

In relation to Next Generation Networks (NGNs) Cave (2008)[46] suggests that if the upstream firm accrues a large investment in sunk costs, the downstream firm has the option to neglect new services made available to it, in effect to "hold up" the upstream entity's investment. Cave suggests that contracts could help overcome this problem, but whether they would succeed or not depends on whether one is a contract optimist or pessimist (p. 21)

Ergas (2007) also recognises that contracts between parties could prevent them from expropriating each other's investment returns, but says that such

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[45] The others are pricing, service quality and "on-going adaptation to change".

[46] Both Cave (2008) and Ergas (2007) appear to be written with the financial support of the Australian incumbent telecoms provider, Telstra, which at the time was opposed to the separation of its business.

contractual means are often an incomplete remedy to the hold-up problem. He then says that vertical integration internalises the gains from the investment and removes the incentive for opportunistic behaviour.

Concern about the "hold-up" problem is, however, also misplaced for two reasons: first, in the presence of a competitive downstream market, investments by the upstream operator would not be relationship-specific; and secondly, internal and external contracting would be sufficient to overcome any "hold-up" problem that might exist. These two points are expanded below.

The "hold-up" problem requires that the investment made by the upstream firm is specific to an individual buyer who can, *ex post*, demand a lower price. However, the presence of a competitive downstream market means that investments made by the owner of the bottleneck facility are unlikely to be specific to any individual customer who cannot then hold up the upstream firm and so demand quasi-rents. Williamson (1979) writes:

> *"The crucial investment distinction is this: to what degree are transaction-specific (non-marketable) expenses incurred. Items that are unspecialised among users pose few hazards, since buyers in these circumstances can easily turn to alternative sources, and suppliers can sell output intended for one order to other buyers without difficulty. Non-marketability problems arise when the specific identity of the parties has important cost-bearing consequences. Transactions of this kind will be referred to as idiosyncratic."* (Williamson, 1979, p. 239)

Alternative buyers of idiosyncratic investments are few, meaning that the buyer can hold up the seller once the seller has made the investment. This is not the case in telecoms markets where there are many downstream buyers of the bottleneck asset.

Suppose that a downstream firm requests an upgraded service from the upstream firm and that, after making the investment, the downstream firm decides not to take the product at the price offered. The upstream firm is not restricted from offering, and may in fact be required by regulation to offer, its services to all downstream firms under a non-discrimination regulation. If the service is seen as something necessary for competitiveness by the downstream business, then that business is unlikely to allow its competitors to have access to the service while it waits for the price to fall. In other words, the asset in which the upstream firm invests is not relationship-specific and can be sold to other operators.

Even in the absence of such a requirement, rational upstream managers are unlikely to make a major relationship-specific investment where they could be held up, when they could develop the service in a way that could be used by other firms in the downstream market.

For example, suppose that the upstream firm invests in NGA. It is highly unlikely to do so in a way in which only one downstream customer could make use of the NGA network. It is far more likely to build its NGA in a way in which any of its customers could use it to compete for retail business. Indeed, under the EoI

obligation, it would be required to make the investment available to all its customers on the same terms.

In fact, the vertically integrated firm is the stronger position as it can refuse to develop a new product, or produce one more suited to its own needs. Even if it did produce the new product, in the absence of price controls it could seek to charge the monopoly price to its downstream rivals.

The debate in the literature is between those who consider separation, including functional separation, to be harmful to efficiency and those who consider that any loss of efficiency is a price worth paying to reduce or eliminate the problems of discrimination. We can now refer back to the discussion in Section 2.6.2 on behavioural and structural remedies and examine functional separation: is it behavioural or functional?

Motta (2004) distinguished a behavioural from a structural remedy by saying that a behavioural remedy places a constraint on property rights and a structural remedy modified property rights. Functional separation does not modify property rights in that Openreach remains a division of BT Group plc. Indeed, as has been pointed out above, it is not even a subsidiary of BT Group plc and any company that buys from Openreach contracts with BT. Thus BT's property rights have not been modified in any way.

However, its behaviour is constrained by the Undertakings, which set out rules and processes by which Openreach and the rest of BT may interact. Annex 2 of the Undertakings lists the job functions and individuals within BT Group (including Openreach) who may share information. The type of information that may be shared is prescribed elsewhere in the Undertakings, for example in Clause 5.39.

The Undertakings specifically allow for investment co-ordination with major investment programmes requiring sanctioning by the Board of BT plc. If the critics of separation were correct, the £2.5 billion investment BT has made on Next Generation Access would be subject to the "hold-up" problem, which occurs when relationship specific investments are made. Unless contracts are perfect, the specificity of the investment makes the investor susceptible to ex-post haggling by the other party. Conscious of such behaviour, the investor is likely to under-invest because investors cannot guarantee themselves a sufficient share of the return through ex-post bargaining.

However, BT's investment in NGA is not relationship specific. On the contrary, because BT has SMP in the relevant market, it must make access available over its NGA network to other operators, for example EE[47], Sky and TalkTalk. No operator would therefore be in a position to indulge in *ex post* haggling as the other, and BT's own retail divisions, could gain a competitive edge while that haggling proceeds.

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[47] At the time of writing this thesis, BT was in exclusive negotiations with EE's owners (Orange and Deutsche Telekom) to acquire EE.

The choice between full-blown structural separation, and some more behavioural remedy is a trade-off between the efficiency gains from integration and the competition gains from separation. Proponents of vertical integration argue that the co-ordination advantages arising from integration result in short-run efficiency gains that outweigh any competition problems that may exist. At the extreme, proponents may reject the notion that competition problems can exist as either the "one monopoly profit" theory would prevent profits being earned at more than one level of the value chain and, anyway, the self-correcting mechanisms of the market would ensure any competition problems are transient. Arguments for vertical integration may be seen as against competition rather than against separation, if a lack of competition allows firms to be more efficient.

By contrast, proponents of separation start from an assumption that competition problems in the monopoly part of the value chain are non-transitory. High barriers to entry mean that an economic bottleneck will be present even in the long run and it would be better to allow competition in, where the market can support multiple firms. Any short-run, static efficiency loss from separation will be outweighed by dynamic efficiency gains in the market segments that can support competition. The problem of lost co-ordination can be overcome by contracts and the hold-up problem won't exist because the monopoly upstream firm serves several downstream firms.

The task of the regulatory or competition authority is to chose between these two arguments and set any gains from one against potential losses from the other.

4.4   Pricing of Local Loop Unbundling in the UK

At the same time as Ofcom issued its Statement arising from the TSR, it also launched reviews of the Wholesale Local Access (WLA) market and of BT's cost of supplying unbundled local loops. The effect of these various reviews was to cut the regulated price at which BT supplied both fully unbundled and shared access local loops to other communications providers. The price control imposed by Ofcom set the maximum price BT could charge for unbundled local loops at a rate much lower than was the case before the new charge control.

The review of the Wholesale Local Access Market (WLAM) was launched in May 2004 (Ofcom, 2004C). The market review followed the standard three-part approach of market definition, assessment of Significant Market Power (SMP) and imposition of obligations on firms with SMP.

The market was defined as consisting of the metallic path running from the Network Termination Point in the customer's premises to the Main Distribution Frame (MDF) located in the nearest telephone exchange building. Ofcom conducted the usual Hypothetical Monopolist Test (HMT) to determine if a cable connection supplied by, at the time, ntl and Telewest (which later merged to form Virgin Media), would belong in the same relevant market. It found that a SSNIP[48]

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[48] Small but Significant Non-transitory Increase in Price.

by a hypothetical monopolist would result in sufficient switching from copper to cable to make the SSNIP unprofitable and so concluded that copper and cable access belong in the same relevant market. Cable was found to place an indirect constraint on a hypothetical monopolist of the copper network rather than a direct one. Cable operators did not (and do not) offer a wholesale access product, so a wholesale customer of copper access could not switch to cable[49]. However, if the hypothetical copper monopolist attempted to impose a SSNIP then sufficient switching would take place at the retail level that the resulting reduction in demand for wholesale copper access would make the SSNIP unprofitable.

Other alternative access technologies, such as fibre and fixed wireless, were not considered to be in the same market as their networks were too limited at the time to place an effective constraint on a hypothetical monopolist.

The geographic market was defined as the whole of the UK, outside the Hull area, which was found to be a separate market[50].

Ofcom found that BT had SMP in the market on the basis of its market share, the ubiquity of its network, and the lack of expected competition from other firms.

Of most relevance to this research is the set of *ex ante* obligations imposed on BT as a result of its SMP in the wholesale local access market. Ofcom required BT to provide access on reasonable request to unbundled local loops. It also required that BT's prices for LLU be set on the basis of its Long Run Incremental Cost plus a mark-up for the recovery of common costs ("LRIC+"), and including an appropriate return on capital employed. Long run incremental costs are the costs of investment in the provision of a defined increment of output. Formally, the "long run" refers to the period of time in which the quantities of all factors of production, including plant and other assets, are variable. The duration of the long run is variable depending on the context. LRIC can also be seen as the costs that the regulated firm would avoid if it decided not to provide the regulated services any longer, taking a long run perspective. The costs per unit of output in the increment are the average costs per unit and so LRIC is sometimes referred to as Long Run Average Incremental Costs (LRAIC). However, the "average" is implicit in LRIC and so normally dropped from the acronym.

Rather than set a specific price for an unbundled local loop, Ofcom decided to set a price ceiling, on the basis that the cost data were largely based on forecasts that were "open to interpretation" (Ofcom, 2004D, para. 9.2). Table 9.2 in Ofcom's Statement set out the proposed ceilings and is reproduced below.

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[49] Whether a wholesale cable access product could be made available is a moot point. In Belgium, for example, the two cable providers are required to provide wholesale access.

[50] For reasons lost in the mists of time, the city of Kingston upon Hull retained, and still retains, a separate telecommunications network that is not part of BT but operated by KCOM, formerly Kingston Communications. The market conditions and obligations imposed in the Hull area are not considered in this thesis.

Figure 11: LLU Price Ceilings 2004

Local Loop Unbundling Service	Type of Charge	(£)
Shared Metallic Path Facility	Rental per annum	12.64
Shared Metallic Path Facility	Connection	37.03
Metallic Path Facility Transfer	Connection	50.70
Metallic Path Facility New Provide	Connection	192.64

(Ofcom, 2004D, para. 9.59)

In 2005, Ofcom launched two other consultations that affected the regulated price of unbundled local loops: one of BT's Weighted Average Cost of Capital (WACC) and one on the valuation of BT's copper access network.

In the WACC Statement[51] (Ofcom, 2005B), Ofcom determined that BT's financial risk associated with its copper access network was lower than the risk for the rest of the company. Therefore, Ofcom declared that the cost of capital allowed for in the regulated prices of copper access products, including LLU, should be lower than for non-copper-based products (e.g. Ethernet services provided over fibre). Ofcom's justification for applying a different, lower WACC was simply that the costs and demand conditions for the copper network were better known and more stable than for other products and services provided by BT. Therefore BT's risk associated with the copper network was lower. At the heart of this consultation was the level of Beta (β) that should be applied in the WACC calculation for the whole of BT and for the copper access network. The Beta is a variable in the WACC calculation that measures the degree to which the returns on a particular financial asset track those of the rest of the market. If $\beta=1$, there is a strong covariance between the returns on the relevant asset and on the benchmark market as a whole. However, if $\beta<1$ then the returns on the asset fluctuate less than the market as a whole and the investment can be considered relatively safe. A $\beta<1$ would imply a lower cost of capital and would thus lead to a lower price for a regulated asset.

Ofcom found that the value of Beta for the copper network was indeed lower than for the rest of BT and that it should be in the region of 0.8 – 0.9 for the copper network compared with 1.14 – 1.23 for the rest of BT. The lower WACC led to a lower price for LLU and other copper access products.

In the second consultation on the valuation of BT's copper access network (Ofcom, 2005C), Ofcom concluded that its preferred approach was to continue with BT's then-existing method for determining the cost of the copper loop but to disallow that element of the over-recovery which had not been crystallised but would otherwise do so in the future (Paras. 6.4 – 6.9).

The details of Ofcom's proposals are not relevant to this thesis. However, the effect of Ofcom's decisions was a reduction in BT's WACC and a lower valuation

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[51] Ofcom refers to "consultations" even after the consultation is closed. Ofcom publishes one or more "Consultation Documents" whilst the consultation is open and a "Statement" at the end of the process.

of the copper access network. These reductions in turn lowered the prices BT could charge for access over the copper network including, crucially, the price for LLU. Table 2 shows the impact on the valuation of BT's copper network calculated by Ofcom dependent on the WACC set (Ofcom, 2005C, paras. 7.13 – 7.16). In essence, dependent on the parameters chosen by Ofcom, the regulated prices that BT would be allowed to charge for key products used by other communications providers would be very much lower than before.

Impact on copper valuation / Copper WACC	Low	High
13.5%	-4.8%	-14.2%
10.3%	-14.6%	-24.1%

Table 2: Reduction in Copper Valuation

Table 3 shows the average monthly charges for LLU in the five largest EU countries in 2003 and 2005. These prices include one-off, set-up costs per line amortised over three years. As can be clearly seen, prices in the UK were very much higher than the other four countries in 2003, but that these had been substantially reduced by 2005 once the impact of the consultations discussed above had been factored in. The price of fully unbundled local loops had been reduced by 56%, whilst the prices of shared access local loops had been reduced by 85%.

		France	Germany	Italy	Spain	UK	Average
October 2003	Full LLU	17.10	16.50	11.00	14.00	25.50	16.22
	Shared Access	9.42	11.01	6.51	5.74	22.59	11.05
October 2005	Full LLU	10.90	11.80	9.30	12.00	11.20	11.04
	Shared Access	4.39	3.74	4.14	3.84	3.34	3.89

(European Commission Implementation Reports. All prices in Euros.)

Table 3: LLU Prices 2003 - 2005, EU5

In Chapter 5 of this thesis the impact of the price reduction and of the implementation of the Undertakings will be assessed in relation to the development of the market for broadband using LLU access.

4.5   The Office of the Telecoms Adjudicator

A third change introduced by Ofcom was the creation of the Office of the Telecommunications Adjudicator (OTA), an independent (of both Ofcom and the industry) body consisting of BT and Communications Providers. The OTA's task was, and remains, to oversee co-operation between communications providers to support the development of a competitive environment. The OTA's primary task is to deal with major issues affecting the rollout and performance of products provided by Openreach, in particular LLU.

The OTA was needed because one of the main concerns raised in the TSR was that the process for implementing LLU was not fit for purpose, and a poor process allowed BT greater opportunity for discrimination, whether deliberately or otherwise. The OTA's main function was therefore to bring the industry together to agree on a suitable process that would reduce that opportunity. It describes itself as having five functions that are within "scope":

" • **Product functionality** - … the definition, specification (including timing of availability) and functionality of In-scope Products and associated facilities and activities necessary for In-scope Products, including (but not limited to) the publication of key performance indicators and progress against plans;

• **Process specification** - … the specification and availability of the processes involved through the life-cycle of relevant In-scope Products and other process specification which will also include facilitating the agreement of reasonable quality levels, service level agreements and service level guarantees … ;

• **Change management** - … modifications, enhancements and improvements of products and processes;

• **Implementation plans** - … the implementation of new and changed In-scope Products and processes and will include, [sic] the project plans, timescales and reasonable resourcing required to delivery [sic] these products and processes; and

• **Monitoring activities** - … necessary on-going activities to monitor implementation of non-binding recommendations of the OTA2 – [including] the use of appropriate key performance indicators where relevant."[52]

"In-scope Products" are Local Loop Unbundling, Wholesale Line Rental, Carrier Pre-Selection, Geographic Number Portability and Broadband migration.

One of the key tasks of the OTA is to monitor and publish the performance of Openreach against Key Performance Indicators (KPIs) that show how well it is achieving its targets for provision and quality of service.

The OTA can be considered to be an essential part of the package of reforms introduced by Ofcom as, in large part, its role was to ensure the effective implementation of the Undertakings by making that the underlying processes were fit for purpose.

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[52] Office of the Telecommunications Adjudicator (no date) *OTA2: Vision*. Available at http://www.offta.org.uk/vision.htm. (Accessed: 3 February 2015).

4.6   Experience in Other Countries

The United Kingdom is not the only country to have introduced some form of separation in the telecoms sector. This part of the thesis reviews the different approaches taken in Italy, New Zealand and Sweden where different forms of separation have been introduced with the aim of addressing the problem of discrimination. This section first reviews features of separation and secondly how the terms of non-discrimination compare with the UK's Equivalence of Input.

4.6.1   Separation

Table 4 summarises the separation commitments in Italy, New Zealand, Sweden and the UK. Each of the features of separation are discussed below the table.

	Italy	New Zealand	Sweden	UK
Legal status of Access Services Division	Division	Separate company	Subsidiary	Division
Separate Premises	No	N/a	Yes	Yes
Own Identity	No	N/a	Yes	Yes
Employee Code of Conduct	Yes	N/a	Yes	Yes
Separate Management Incentives	Only non-financial	N/a	?	Yes
Independent Supervisory Board	Yes	N/a	Yes	Yes
Degree of Separation	5	8	6	5

Table 4: Summary of Separation Status in Selected Countries

Legal Status of the Access Services Division

Until 2009, Telecom Italia (TI) was under an obligation of Accounting Separation imposed in 2002 by AGCOM, the Italian regulator, under decision 152/02/CONS. This decision characterised the activities that had to be classified in its separated accounts. More specifically, the decision defined (a) the entity with responsibility for a particular regulated service, (b) the way in which profit and loss accounts and the balance sheet had to be prepared, and (c) the approach for documenting transfer charges within the company (Nucciarelli and Sadowski, 2010). Despite the obligation to produce separated accounts, by 2009 accounts had only been published for the years 1999, 2000, 2001 and 2004. Accounts for 2005 and 2006 had been lodged with the regulator but were still being audited.

By 2008, Telecom Italia had been the subject of several investigations for breaches of SMP conditions imposed by AGCOM. In 2007 and 2008 four breaches were notified relating to non-discrimination. It had already been fined for breaches on retail products, in particular Carrier Pre-Selection and Mobile Number Portability. To avoid further fines, Telecom Italia presented a set of voluntary "Commitments" to AGCOM, in return for which the investigation of the breaches was suspended. The Commitments were accepted by AGCOM and came into effect on January 1st 2009 under AGCOM Decision no. 718/08/CONS[53].

Under The Commitments, Telecom Italia set up "Open Access" (OA) to provide access services to the Retail Commercial Directorate of Telecom Italia and to other operators through the National Wholesale Services corporate function. The function of Open Access is to manage:

> "•   *All the activities for the development and maintenance of access network technological infrastructures;*
> •   *The processes for the supply of access services for Telecom Italia clients and clients of other operators, with the related technical assistance."* (Telecom Italia, 2014A)

OA appears to be more closely integrated with Telecom Italia than Openreach is with BT, as it is a business unit within the Technology Division of Telecom Italia. The manager of Open Access reports to the manager of the Technology Division (Telecom Italia, 2014C) According to Telecom Italia:

> "access services are delivered by Open Access to the retail commercial functions of Telecom Italia and to other operators through the National Wholesale division. The activities of Open Access and National Wholesale Services for the production of access services are separate and managed autonomously from Telecom Italia Group's other commercial operations." (Telecom Italia 2014B)

The implications of this arrangement for non-discrimination will be discussed later.

New Zealand has taken a very different regulatory approach to that taken in the EU, and has now gone further than the UK by separating Telecom New Zealand (TCNZ) into two separately owned entities.

New Zealand began to reform its telecoms industry in 1987 with the passing of the Telecommunications Act 1987. This ended TCNZ's statutory monopoly over the supply of telecoms services by 1989 and introduced a form of "light touch" regulation that was restricted to *ex post* interventions under the competition law.

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[53] 'Telecom Italia's Commitments' As approved by AGCOM Decision no. 718/08/CONS 15 December 2008. Non-binding translation.

There was no *ex ante* sector-specific regulation. This meant that most disputes between TCNZ and entrants ended in the courts with at least one interconnection case being finally decided by the Privy Council in London: the highest court for New Zealand.

In December 2001, the New Zealand parliament passed the Telecommunications Act 2001, which placed responsibility for the regulation of the telecoms sector on the Commerce Commission. Although the Commerce Commission had some *ex ante* powers, there was still a preference for market-based solutions. For example, although the Commerce Commission ruled that TCNZ did not need to introduce LLU, TCNZ itself agreed with the government that it would deliver 250,000 more broadband lines by 2005, one third of which would be wholesale through other providers. This market solution was seen as preferable to a regulatory approach (Bleisch and Marcus, 2010).

A review of the 2001 Act in 2006 (the "Stocktake") led to various amendments to the Act that in turn led to a set of Undertakings by TCNZ to the Minister of Communications in March 2008 that were later varied in June 2009 (TCNZ, 2009). In common with the BT/Ofcom Undertakings of 2005, TCNZ's Undertakings addressed both the organisation structure of TCNZ and introduced Equivalence of Input.

The New Zealand Undertakings, in contrast to the UK equivalent, specified three business units[54]: Access Network Services, Wholesale and Retail, illustrated in Figure 12. The ANS division was branded as Chorus.

In September 2009, the New Zealand government announced its plan to fund and develop a nationwide fibre broadband network in partnership with private capital and that it had established Crown Fibre Holdings Ltd as its investment vehicle. The government's plan is that 75% of New Zealanders will be connected to ultra-fast broadband by 2020. The government defines Ultra-Fast Broadband as downlink speeds of at least 100 Mbps, and uplink speeds of at least 50 Mbps. The government is contributing NZ$1.35 billion (£660 million) to the initiative with "significant amounts of private co-investment" being contributed by the government's Ultra-fast Broadband partners.

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[54] This arrangement is sometimes referred to the "three box solution". The three boxes being ANS, Wholesale and Retail.

Figure 12: Organisation of TCNZ 2009
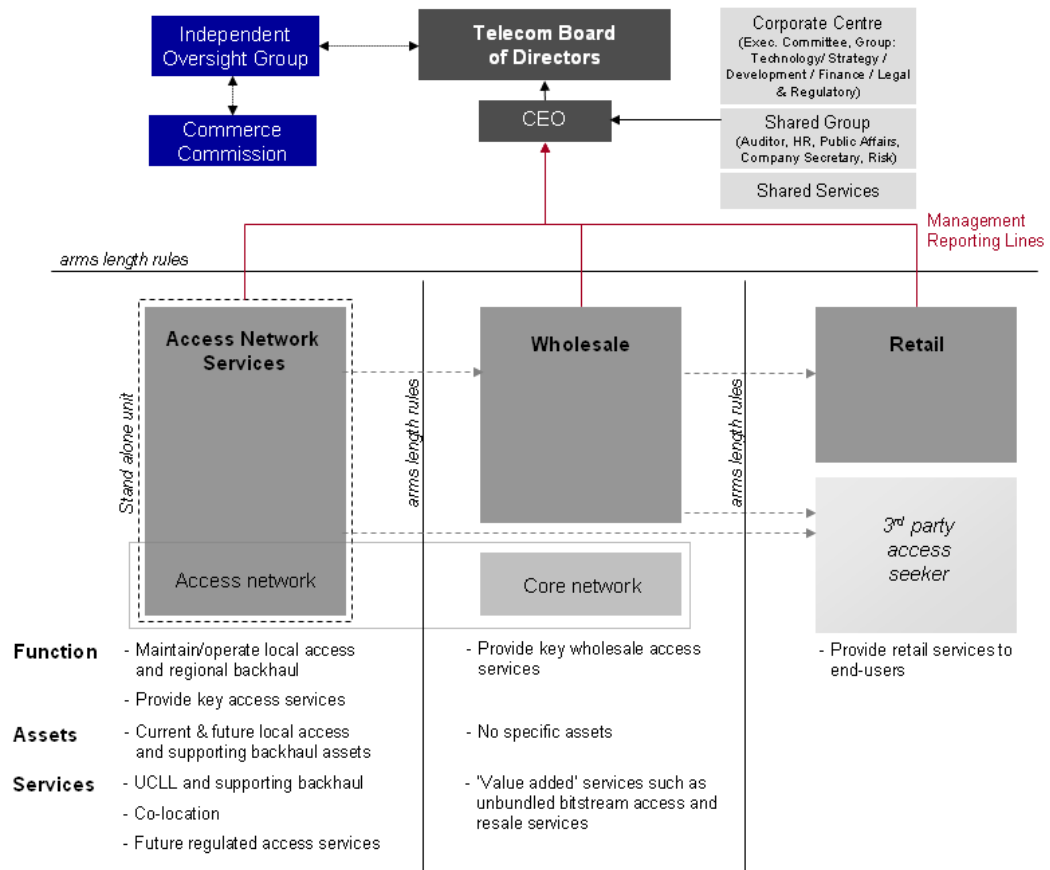
(Bleisch and Marcus, 2010)

Crown Fibre Holdings monitors Ultra-Fast Broadband deployment and the contracts with "local fibre companies" (the companies that will roll out the new network in partnership with the government). One of the restrictions placed on local fibre companies was that they could not be involved in retailing services, which would exclude Chorus from bidding to be a partner in the UFB project.

In the summer of 2010, TCNZ announced that it was considering structurally separating Chorus from the rest of the company to create two separate companies. Chorus2, as it was referred to, would operate the copper access network and would undertake any investment in fibre. A key policy objective for the government arising from separation was to require business restrictions on Chorus2 to bar it from participating in markets where "it would have an undue advantage arising from its market power in upstream access network service markets" (Ministry of Economic Development, 2010).

Following structural separation, Chorus2 would provide both LLU and bitstream services. As LLU is an upstream input to bitstream, Chorus2 would still have an incentive to deter competitive supply of bitstream by firms that buy LLU from Chorus2 and then wish to supply bitstream in competition with it. The Ministry therefore came to the view that the EoI obligation in the New Zealand Undertakings should remain in force for Chorus2 such that Chorus2 supplied LLU

internally and to third party access seekers under the same terms and conditions and so forth. However, the Ministry thought that it would be disproportionate to require Chorus2 to operate as two business units.

The possibility for Chorus2 to continue to discriminate was therefore not entirely eliminated by the structural separation of TCNZ. So long as Chorus2 was vertically integrated and had upstream market power, it could still harm the market without the continuing requirement to offer downstream services on an EoI basis.

In December 2011, the structural separation of TCNZ took place with Chorus' shares floated on the New Zealand stock exchange. TCNZ has more recently been rebranded as "Spark".

The Swedish NRA, Post & Telestyrelsen (PTS), published a report in 2007 on how competition in the broadband market could be improved (PTS, 2007). The report found that there were long-term structural problems in the market that neither sector-specific regulation nor competition law had been able to remedy. At the time, TeliaSonera's retail market share in Sweden was around 40%, but its wholesale market share was 70%. The report concluded that a new regulatory tool was need to rectify the situation and that this tool should be functional separation.

PTS identified two "positive qualities" of functional separation: first it is proportionate in that it "rectifies the problems of equality of access that need to be resolved" and secondly it has been "tested and shown to function in the United Kingdom" (PTS, 2007, p. 10).

The report stated that the opportunity to impose functional separation would arise in the next market review and a decision regarding Significant Market Power. However, PTS also proposed that powers should be introduced into the Electronic Communications Act (LEK) to allow it to accept voluntary commitments to bypass the formal regulatory route.

On 1st January 2008, TeliaSonera, the Swedish incumbent operator, voluntarily set up a separate subsidiary, Skanova AB, to provide copper related infrastructure on the same commercial terms to all operators in Sweden. Skanova also now provides dark fibre access in around 100 towns in Sweden[55].

The legal separation of TeliaSonera was implemented voluntarily by the firm. However, the government did make the necessary legal changes that would have allowed it to impose functional separation had it not happened voluntarily. (Such pre-emptive behaviour by the incumbent was predicted in de Bijl (2005) in the form of a game between the regulator and the incumbent). The law, however, came into effect some six months after the creation of Skanova.

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[55] From Skanova's website www.skanova.se Accessed December 2014

The timing of actions by TeliaSonera, PTS and the government are set out in Teppayayon and Bohlin (2010), reproduced in Figure 13.

Figure 13: Functional Separation Process in Sweden
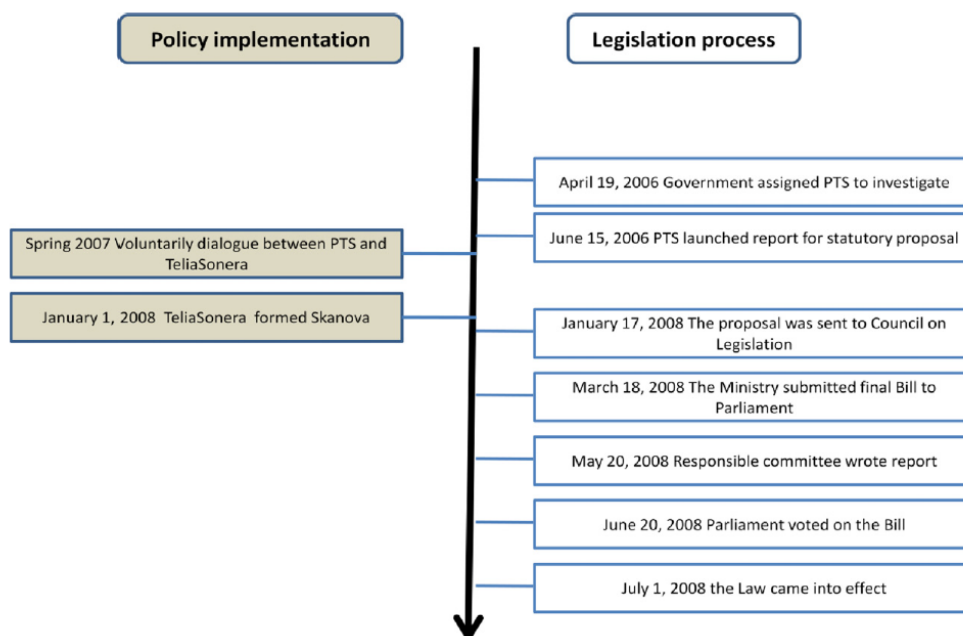
Separate Premises

The physical separation of BT and Openreach management and staff was a specific requirement of the UK Undertakings. The Italian Commitments are silent on the need for separate premises, except that the Supervisory Board should be located separately.

Chorus2 is a separate company from Spark and is located in separate buildings.

Skanova's head office address is different from that of TeliaSonera Sweden, but is located very close to TeliaSonera's international carrier services division.

Separate Identity

Open Access does not have a separate brand or identity from the rest of Telecom Italia, whereas Chorus, Skanova and Openreach all have separate identities. The Skanova brand is more distinct from its parent than the Openreach brand, as there is no indication from the branding that it is part of TeliaSonera, as can be seen in Figure 14.

Figure 14: A Skanova Van

Separate Management Incentives

The UK Undertakings make it clear that Openreach management and staff are only to be remunerated on the basis of the performance of Openreach and not the rest of BT.

The Italian Commitments introduced a new incentive system, but these are not related to the financial performance of Open Access, but to non-financial targets such as the satisfaction of the Operators purchasing services from Open Access, and the quality, security and efficiency of the fixed access network (Telecom Italia, 2008, para. 2.1).

It is not known whether Skanova has separate financial incentives. However, as it operates as an independent subsidiary, it is a reasonable assumption that it does.

Supervisory Board

Although it remains an operating division of Telecom Italia, rather than a subsidiary, Open Access has a separate Supervisory Board. A new three-man Board took office in 2012. Members of the Board are: Prof. Antonio Sassano (appointed by the Board of Directors of Telecom Italia), Prof. Marco Lamandini (selected by the Authority) and Prof. Michele Polo (selected by Telecom Italia).

The function of the Supervisory Board is to "(i) supervise the proper implementation of the Commitments; (ii) verify compliance of the KPIs referred to in Groups of Commitments 3 and 4 with the principles of equal treatment and the quality objectives for the fixed network access services" (Telecom Italia, 2008, paras. 7.1 – 7. 26).

The Supervisory Board publishes an annual report and a quarterly newsletter setting out their activities. There is also a separate website for the Supervisory Board (http://organodivigilanza.telecomitalia.it/eng/index.shtml).

TeliaSonera has established an "Equality of Access Board" for Skanova "to retain a strong confidence in the principle of equal treatment" [56], but no further information is available concerning this Board. This is most likely because Skanova was established voluntarily by TeliaSonera and not as a result of "Undertakings" agreed with the regulator.

As an independent company, Chorus naturally has completely separate governance arrangements to those of Spark.

4.6.2 Equivalence of Input

The UK Undertakings define EoI as BT providing the same product or service, on the same timescales, terms and conditions, by means of the same systems and processes and including the same Commercial Information (Ofcom, 2005, p. 61). This section of the thesis examines how other countries' approach differs from that taken by BT and Ofcom. The approach taken by the countries is summarised below.

	Italy	New Zealand	Sweden	UK
Same products and services	Yes.	Yes.	Unknown	Yes, although BT uses Shared Metallic Path Facility and Wholesale Line Rental whilst other operators use Metallic Path Facility.
Same timescales, terms and conditions (including price)	No, due to different processes and allocation of costs.	Unknown.	Unknown.	Yes.
Same processes and systems	No.	Unknown but assumed so.	Unknown.	Yes.

Table 5: Equivalence of Input International Comparison

Same products and services

Telecom Italia is not under an obligation of Equivalence of Input, and the Commitments do not purport to require EoI. Rather, Telecom Italia is required only to meet the obligations of Equivalence of Output, which it considers sufficient to ensure a competitive market.

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[56] Taken from http://www.teliasonera.com/about-us/markets-and-brands/sweden/ 5/1/2015

The Italian Commitments do not specifically state that Open Access should provide the same product and services to Telecom Italia and other "Operators". However, they do define a number of "SMP Services" (for example WLR and LLU) and then state that the new single delivery process "shall manage activation, termination, variation and migration of SMP Services, with no distinction between orders coming from the Operators and from Telecom's commercial functions" (Telecom Italia, 2008, para. 1.1). The implication is that the same products and services are provided, and informal discussions with Operators in Italy have suggested this is the case.

Before the structural separation of Chorus, it also operated under a set of Undertakings between TCNZ and the regulator in which Equivalence of Input was defined in almost the same manner as in the UK Undertakings, including the qualification that "the same means exactly the same!" (TCNZ, 2009, Clause 1.2). Now that Chorus is a separate company, it has a defined product set that is available to all wholesale customers meaning that TCNZ and other customers have access to the same products.

Skanova is positioned as a separate infrastructure company that provides services "on the same commercial terms to both TeliaSonera's own end-customer business in Sweden and to other operators"[57] but it is unclear if the same products and services are used by TeliaSonera and other operators. For example, it is unclear if Skanova provides LLU to TeliaSonera or whether a different (internal) product is provided.

Openreach tends to comply with the objective of providing the same product. However, there is one caveat. BT's competitors (for example Sky and TalkTalk) tend to use fully unbundled local loops (known as Metallic Path Facility (MPF)). BT, however, uses a combination of Shared MPF (SMPF) and WLR for largely historic reasons. Therefore BT and its competitors do not use exactly the same input but it is generally considered that BT gains no competitive advantage from this distinction and its competitors do therefore not consider it a problem. Further, although competitors do not use SMPF and WLR, both products are available to them should that combination be more efficient than MPF in a particular exchange.

Same timescales, terms and conditions

Paragraph 1.1 from the 2008 Italian Commitments suggests that products would be delivered to all operators on the same timescales and under the same terms and conditions However, as will be discussed later, the processes used for delivery to Telecom Italia and its competitors are different and therefore it is highly likely that these feature of EoI are not met. In particular, costs appear to be allocated differently, which could result in different prices.

No information is available on whether these conditions are met in Sweden.

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[57] ibid

Same processes and systems

The main area in which the Italian Commitments vary from EoI is the systems and processes that OA uses for providing access services to its retail divisions are different from the systems and processes used for providing services to its competitors, as illustrated in Figure 15. Specifically, whilst Telecom Italia's own retail operations interface directly with Open Access, its competitors first must place orders, etc., through Telecom Italia Wholesale.

Figure 15: Wholesale access provision for TI Retail and competitor service orders
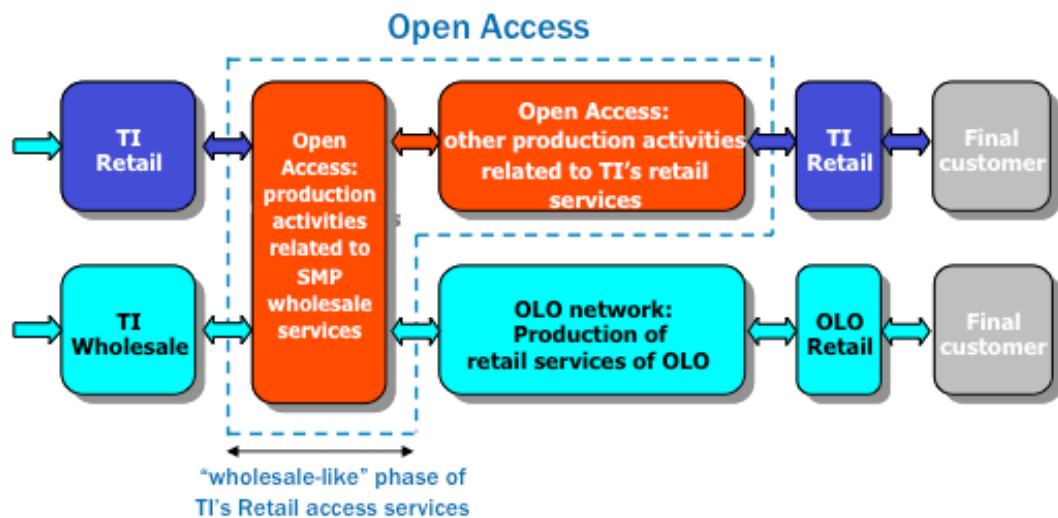
(Telecom Italia, 2009)

(Note: OLO is an acronym for "Other Licensed Operator", meaning a telecoms company other than Telecom Italia. An OLO is referred to in this thesis as an entrant.)

According to Nucciarelli and Sadowski (2010, p.388), the fact that competitors ask for services through Wholesale "implies that the degree of cost transparency provided by Open Access is lower than that guaranteed by Decision 152/02/CONS". This happens because OA not only provides copper lines that are subject to natural monopoly, but also the active services based on those copper lines and the additional costs of these active elements can be allocated to OA.

Nucciarelli and Sadowski also make the point that competitors pay the entire cost of the wholesale division. TI Retail interacts directly with OA and so does not pick up any costs of Wholesale. However, OA's costs are attributed to both Retail and Wholesale. Thus competitors' costs are raised above those of TI Retail. If they are correct in this analysis, then this implies that entrants are likely to pay a higher price than TI's retail divisions and therefore would be unable to compete effectively.

The structure also allows OA to distinguish and, therefore, discriminate between the orders coming from TI retail and its competitors. For example, TI has, allegedly, repeatedly refused to activate wholesale access services to Operators by rejecting the orders because of technical reasons - the so called "KO" (Antitrust proceeding A 428 - still proceeding).

Further, the access services are not provided to competitors and to TI on the same timescale. Whereas TI retail directly interacts with Open Access for technical/commercial provision of the access services, competitors have to interact with TI wholesale first which, in turn, interacts with OA, as indicated in Figure 15. The result is that process lead-time is longer for competitors' requests, whose orders have to be processed by TI Wholesale first before being sent to OA for delivery process. This affords TI the opportunity to discriminate in favour of its own retail customers.

For example, Antitrust proceeding A 426, closed in June 2012 with the acceptance of a set of commitments from TI, concerned Different Service Level Agreements between TI and Other Licensed Operators (OLOs). The level of assurance provided to TI Retail was found to be more favourable than the level provided to OLOs.

Sections 3 and 4 of the Commitments concern establishing a performance monitoring system and transparency of the monitoring system respectively. According to paragraphs 3.2.2, 4.8 and 4.9, Telecom Italia must analyse the performance for internal and external access seekers separately and must publish the data on a quarterly and annual basis on a website dedicated to Operators[58]

However, TI Retail and Operators follow different processes in their interaction with OA, meaning that the KPIs provided by Telecom Italia compare different processes. Whilst it may still be possible to compare outcomes, this does mean that the only equivalence is that of outcomes not inputs.

There is no information available concerning the processes used by either Skanova or Chorus and whether these are the same for all customers.

4.6.3 Outcomes

Data are not available to compare the outcomes of the various approaches to separation and EoI on the same basis as will later be done for the UK. However, it is possible to track the development of market shares at retail level and, for some countries, at wholesale level.

In Italy, Telecom Italia remains the largest broadband provider at retail level. According to the European Commission, at the end of 2013 its market share stood at 51.4%, down from 60% in 2008 but still some nine percentage points

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[58] www.wholesale-telecomitalia.it

above the average of an incumbent operator in the EU (European Commission, 2013B). The number of LLU lines has increased from 2 million in 2007 to 5.3 million at the end of 2013, respectively 20% and 38% of the total number of broadband lines.

Overall, the Commitments have not been as effective at preventing discriminatory behaviour as they may appear to be in principle. In June 2010 the Italian Competition Authority (AGCM) launched an investigation concerning Telecom Italia's discriminatory behaviour. The complaint concerned the high number of rejections of rivals' requests for activations of wholesale access lines to provide services to end users, referred to as "technical boycotting".

AGCM found that between 2009 and 2011 TI had unfairly rejected a number of requests for activation of wholesale services. It had also discriminated against requests coming from other operators by obstructing competitors' access to its infrastructure and making service access activations significantly more difficult. As a result the AGCM imposed a fine of €88.2m on TI.

TCNZ's share of the retail broadband market has declined substantially since 2007, from 70% to 49%, but has flattened off since 2011, as shown in Figure 16. There are insufficient data to attempt to determine any causal link between the operation and then structural separation of TCNZ and market shares, however, it should be noted that the decline in the market share of TCNZ had begun before the New Zealand Undertakings came into effect.

Figure 16: TCNZ Broadband Market Share 2007 - 2013
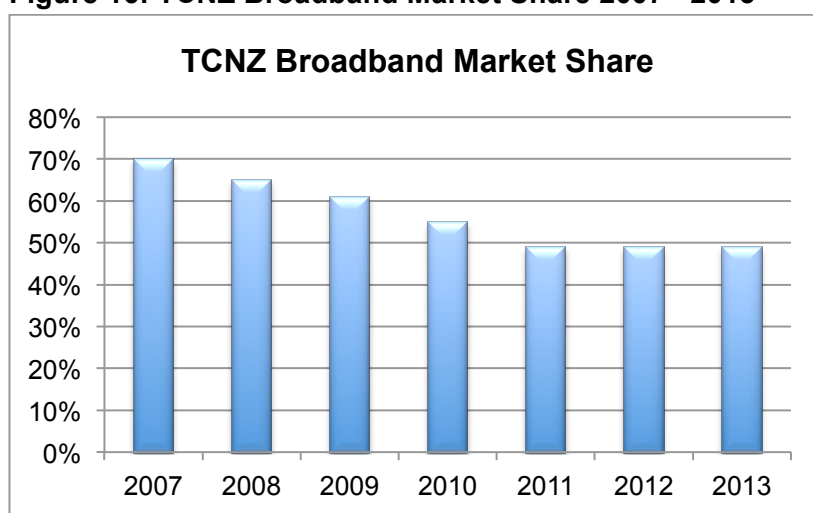
(Commerce Commission, 2014 and earlier versions)

The number of unbundled local loops has increased massively since 2008, as shown in Figure 17. However, at 120,000 lines this represents less than 10% of broadband lines, which compares poorly with EU countries such as France and the UK and indicates there is still an opportunity for strong growth.

Figure 17: Unbundled Local Loops in New Zealand
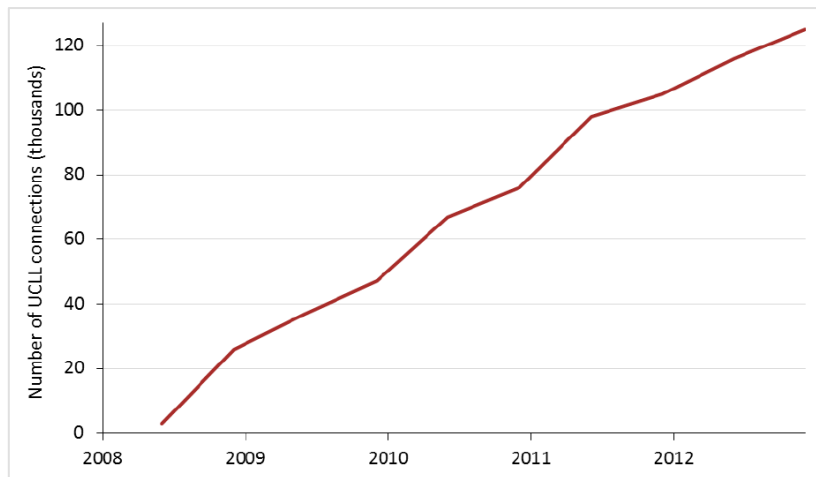
(Commerce Commission, 2013)

In Sweden, TeliaSonera's share of the retail market has remained static at around 39% since 2009 (PTS, 2014, fig. 20). Copper-based broadband access using DSL accounts for just 44% of all broadband lines in Sweden, well below the EU average of 72%. Of the three million DSL lines, around 400,000 are LLU lines.[59]

4.6.4 Summary on Other Countries

In two of the three cases of business separation reviewed above, the firm remains intact with the upstream monopoly business unit remaining an operating division or, in the case of Skanova, a subsidiary within the group. The separation terms impose various constraints on the regulated firm, for example management incentives based only on the performance of the upstream business and restricted communication between the functionally separate entities. However, as it does not "modify the allocation of property rights" it is more properly considered a behavioural remedy. In only one case, New Zealand did the firm structurally separate and then voluntarily, rather than as a regulatory requirement.

Further, functional separation is a means to an end and not an end in itself (Cadman, 2010; Howell, 2010; Krämer and Schnurr, 2014). The end it is trying to achieve is deterrence of price and non-price discrimination by the vertically integrated firm, and thereby creation of the conditions for effective competition in retail markets. Open Access, Skanova and Openreach are all under various non-discrimination obligations in an attempt to achieve this aim by changing incentives to a greater or lesser extent. This obligation also does not affect property rights and so is very clearly a behavioural remedy.

By contrast TCNZ decided to create separate companies so that the upstream company, Chorus, could participate in the UFB project, which it would not have

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[59] Based on European Commission Data in "Broadband Indicators" available at
https://ec.europa.eu/digital-agenda/en/fast-and-ultra-fast-internet-access-analysis-and-data.
Downloaded 9 January 2015.

been able to do had it remained a part of TCNZ and so integrated with a retail business.

4.7 Other Sectors

The electronic communications sector is not the only one that has faced the problem of discrimination by a vertically integrated firm with market power upstream. In this subsection, the approach taken in the UK gas market and the electricity supply market in England and Wales are examined.

4.7.1 British Gas

Until 1982 the British Gas Corporation (BGC), a nationalised industry, had a statutory monopoly on the purchase of gas from the North Sea basin, although the gas fields themselves were developed by private sector businesses. BGC retained that right until 1982 when it was ended by the Oil and Gas Enterprise Act (Weir, 1999). The 1982 Act also introduced potential competition to retail gas, although this was limited to large industrial and commercial users.

Gas supply was privatised under the Gas Act 1986. BGC, which became British Gas plc, was privatised as a fully vertically integrated company involved in the extraction, storage, distribution and supply of gas. British Gas remained a licensed monopoly except for customers using more than 25,000 therms per year, reduced to 2,500 therms by 1990. However, competitive access was left to entrants to negotiate with British Gas, although they could appeal to the sector regulator, Ofgas. Between 1982 and 1990 there were ten attempts to secure access, all unsuccessful (Newbery, 2001).

In 1987 the OFT referred the supply of gas through pipes to non-tariff customers to the Monopolies and Mergers Commission (MMC). These were customers using more than 25,000 therms per annum and were therefore industrial users. The MMC found "extensive discrimination by BG in the pricing and supply of gas to contract customers" which it attributed to "the existence of a monopoly situation and operates or may be expected to operate against the public interest in a number of respects (MMC, 1988, 1.3). The MMC identified three specific ways in which BG was able to harm consumers and the broader public interest. First, price discrimination imposed a higher cost on users less well placed to use alternative fuels. Secondly, "BG's policy of relating prices to those of alternatives available to each customer places it in a position selectively to undercut potential competing gas suppliers" (MMC, 1988, 1.3). Such behaviour could, according to the MMC, restrict the development of competition in the market. Thirdly, the lack of transparency created uncertainty about future prices in the minds of customers leading to increased risk.

The MMC made a number of specific recommendations. Specifically in relation to prices it proposed that BG should:

> *"1)   Publish a schedule of prices at which it is prepared to supply gas to contract customers and not to discriminate in pricing or supply; and*
>
> *2)   Publish further information on common carriage terms such that a potential customer could make a reasonable estimate of the charge that would be sought by BG."* (MMC, 1988, 1.6).

A further reference was made in 1992 requiring the MMC to investigate two subjects: the supply of gas through pipes to tariff and non-tariff customers, and the conveyance of gas by public gas suppliers.

The MMC reported in 1993 and found that British Gas plc's ownership of both transport and trading led to "an inherent conflict of interest which makes it impossible to provide the necessary conditions for self-sustaining competition" (MMC, 1993, 1.6). British Gas was found to have used its market power to deter entry and competition (Newbery, 2001) and the failure to separate out transportation and trading costs made it impossible to treat BG Trading on an equal footing with rival traders (Stoppard, 1993). The MMC recommended that the trading activity of British Gas should be divested from the rest of the company leaving British Gas with just transport and storage to ensure equal access to these services by downstream competitors (MMC, 1993, 1.11). However, the Department of Trade and Industry rejected this proposal in favour of accounting separation.

Competition for domestic customers was first introduced in the southwest in April 1996, extending to all parts of the country by May 1998 and the UK was the first country in the world to introduce competition in gas supply (Hancock and Waddams Price, 1996).

In 1997 British Gas voluntarily separated along the lines proposed by the MMC in 1993. Most of the assets were transferred to BG plc, which owns the onshore pipeline and storage systems and Exploration and Production. The trading arm, British Gas Trading, became part of the newly formed Centrica plc.

The degree of competitiveness in the gas market is still open to question. Some top level numbers would indicate that there has been an increase in competition. In 1996, Centrica supplied 19 million domestic customers. By 2000, about 30% of customers had switched suppliers saving around 15% on their annual gas bill (Newbery, 2001) and by September 2013 Centrica's market share had fallen below 40% (Ofgem, 2014).

However, in June 2014 the Competition and Markets Authority (CMA) opened an investigation into the energy markets, including gas and electricity supply, following a referral by the Gas and Electricity Markets Authority, the governing body of Ofgem. The terms of reference for the investigation state:

> *"The Gas and Electricity Markets Authority has reasonable grounds for suspecting that a feature or a combination of features of the market or*

markets for the Supply and Acquisition of Energy in Great Britain prevents, restricts or distorts competition." (CMA, 2014)

The CMA states that there are broad public concerns about prices and quality of service in energy markets that justify the market investigation. The CMA is scheduled to report its findings in December 2015. Whether the CMA investigates vertical relationships remains to be seen.

4.7.2   The English and Welsh Electricity Supply Sector

The English and Welsh electricity supply sector has been the subject of substantial regulatory and structural change over the past 25 years. The brief review below considers only whether the unbundling of the sector has been beneficial.

Electricity supply consists of four activities: generation, high tension transmission, local distribution and retail. High tension transmission and local distribution have the characteristics of natural monopoly. Until the Electricity Act 1989, generation and transmission in England and Wales were operated by the Central Electricity Generating Board (CEGB) and twelve regional Boards acted as local distribution and retail monopolies. The CEGB and the 12 Boards were all state-owned.

The 1989 Act divided the CEGB into four separate companies: National Power, PowerGen, Nuclear Electric and the National Grid Company (NGC). The 12 Boards were turned into limited companies and jointly owned NGC. NationalPower and PowerGen were floated on the stock market in two tranches: the first in March 1991 and the second in March 1995. Competition was gradually introduced in the supply market such that by 1998 all households and businesses were able to purchase electricity from competing operators.

The original scheme was for an almost completely unbundled industry with no vertical integration. However, this strict unbundling has been compromised in recent years as generators have entered the retail market. For example RWE npower is both a generator and retailer with around 5.4 million business and residential customers. The national grid, however, does remain a separate business that is not active in generation, distribution or retail.

Pollitt (2008) assesses the benefits of ownership unbundling of energy transmission networks. He concludes that the creation of an Independent Transmission System Operator (ITSO), the National Grid, was a "highly successful reform with competition in generation and a fall of 30% in real transmission charges" between 1993 and 2005, although this reduction was also promoted by incentive regulation. He also finds there was little evidence that investment in transmission was adversely affected by unbundling. Finally, he finds that the top six countries ranked by level of switching by small and very small household customer all had ITSOs.

Paul Joskow is also generally positive about the reform of the electricity sector in England and Wales, describing it as "the gold standard for electricity reform" However, he also recognises that not everything worked perfectly. He says that the decision to create only three generating companies led to significant market power problems that persisted for several years. He also describes retail competition as only "reasonably successful" and says that the benefits of extending competition to retail customers may not have been worth the costs (Joskow, 2008, p. 15 - 16).

The overall success of the reforms to the electricity supply market in England and Wales are likely to become clearer by the end of 2015. Electricity supply is subject to the same market investigation by the CMA as gas, suggesting that problems remain in the market, such that it is not working in the interests of consumers.

4.8   Lessons from Other Countries and Sectors

The approaches to separation taken by the other countries and sectors reviewed here were all designed to address the same problem: the ability of the vertically integrated firms to harm its rivals through non-price discrimination. However, each country and sector has adopted different methods, reflecting specific national and sectorial circumstances. Telecom New Zealand went furthest to ensure that its separated upstream division could benefit from state funds to invest in ultra-fast broadband. At the other extreme, Telecom Italia's separation was minimal and the Open Access division remained part of Technology Division rather than becoming a separate business unit. Telia, in Sweden, introduced legal separation itself before it was forced to do so by law. The UK electricity sector was separated at privatisation, but has since seen some re-integration.

These different approaches make it difficult to draw general conclusions and lessons that could be applied elsewhere. A sceptic might suggest that in all cases the vertically integrated operator did just enough to avoid more drastic structural remedies being imposed on them. Alternatively, it may be that the degree of separation simply reflected national circumstances and the place that each firm started from. It is also the case that there are many countries that have not seen the need for any form of separation, beyond accounting separation. Unfortunately, consistent data are not available to compare the outcomes to determine whether one approach is better or not.

All one can realistically conclude, therefore, is that each country and sector that faces a potential problem of non-price discrimination by a vertically integrated operator needs to draw its own conclusion as to the appropriate model of separation based on national and sectorial circumstances. There is nothing in the evidence here that there is a single "best approach" that could be adopted by any country regardless of their starting point. Rather regulators and firms should examine how other countries and sectors have approached the problem, but should also consider the best approach for their country and sector.

4.9   Conclusions from Chapter 4

Chapter 4 has set out a history of the actions taken by Ofcom to overcome the perceived level of non-price discrimination exerted by BT against its rivals in the UK broadband market. It has also briefly examined similar actions taken by other regulators in the telecoms sector internationally and in other sectors in the UK. The chapter has pointed out that it would be wrong to consider functional separation as the only change imposed on BT in 2005. It was also subject to the specifically *ex ante* form of non-discrimination known as Equivalence of Input and a substantial price cut in LLU.

Ofcom's actions were more draconian that the equivalent actions taken by other EU regulators. Neither Telia nor Telecom Italia were subject to the same level of separation nor, and more importantly, to Equivalence of Input. The UK, therefore, appears to have taken the strongest actions to deter discrimination and amend the incumbent operator's incentives.

Chapters 4 and 5 of this thesis will explore whether the actions taken by Ofcom have been successful.

5   Empirical Analysis 1: Market Entry via Local Loop Unbundling

This thesis has explored the economic principles and market structure issues behind Ofcom's decision to impose Equivalence of Inputs (EoI) and functional separation on BT. The objectives of these reforms were to strengthen the non-discrimination obligation and to reduce the incentives for BT to behave in a discriminatory manner, and thus encourage competitive entry lower down the value chain. This section considers empirically whether the package of measures was successful at reducing the expected costs of non-price discrimination, leading to increased entry by service providers using Local Loop Unbundling (LLU) as the wholesale input bought from BT. The analysis here concentrates on the wholesale market only and does not seek to measure the effects at the consumer level[60].

This chapter is structured as follows.

Section 5.1 sets out two potential methods for measuring the level of discrimination in broadband markets. The first proposed measure is the proportion of LLU to all forms of competitive copper access (CCA). It suggests that the higher the proportion of LLU, the lower the cost of discrimination. The second proposed measure is the location of marginal exchange, i.e. the exchange where the entrant is indifferent between entry using LLU and using BSA. It concludes with two hypotheses: that the regulatory reforms of 2005 (i) increased the LLU:CCA ratio and (ii) changed the marginal exchange to one with fewer premises than would otherwise have been the case.

Section 5.2 tests the first hypothesis using an induced diffusion model based on Davies and Diaz-Rainey (2011). It concludes that a simple graphical representation of the timing of the Undertakings, the price cut and the diffusion of LLU:CCA suggests a causal link. However, it is not possible using such a model to determine such a relationship econometrically, in part because only the UK introduced such reforms so there are no countries to compare it with.

Section 5.3 deploys a breakeven model to determine the location of the marginal exchange before and after the price cut. This is found to have moved by 847 exchanges and to have added a further 9% of households to the economically viable area to unbundle. The section uses the same model to estimate the cost of discrimination before 2005. It locates the marginal exchange by taking the characteristics of the actual unbundled exchanges and applying an adjustment to exclude smaller exchanges that may have been too small to be unbundled economically. The first adjustment places the marginal exchange one standard deviation from the mean number of premises and the second assumes the marginal exchange is at the 10th percentile from the smallest. These adjustments are applied to both 2003 and 2004. With these adjustments the cost of discrimination is estimated at between £495 and £1,323 per exchange reducing

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[60] These effects have been addressed elsewhere, for example. Nardotto, Valletti and Verboven (2012) and Sidak and Vassallo (2014).

the number of exchanges that could be unbundled to between 640 and 1,309. This section therefore separates the effect of the Undertakings and the price cut on the number of exchanges that could be unbundled economically.

Section 5.4 presents a short comparison with the situation in France where the LLU:CCA ratio increased at the same rate as the UK but grew much earlier.

Once the effects of the Undertakings and price reductions on entry by LLU have been established, the thesis then goes on to examine in Chapter 6 whether BT's decision to upgrade its network to Next Generation Access (NGA) was affected more by the presence of service providers using LLU or by the presence of the cable operator, Virgin Media. In this way, the thesis assesses both the short- and long-term effects of the Undertakings on the development of the broadband market in the UK.

5.1   Measuring Discrimination in Broadband Markets

Section 2.4 referred to the theory of raising rivals' costs (RRC) and how a dominant infra-marginal supplier could, through non-price discrimination, seek to raise the costs of the marginal supplier above the market price and so attempt to exclude marginal suppliers from the market. Arrow described discrimination as "some characteristic of an employee other than productivity that would account in difference in wages for the same job" (Arrow, 1973). Arrow's example was black and white steel workers. Discrimination in this case would be relatively easy to observe and to measure: the difference in wages between black and white workers, assuming all other things are equal.

Unfortunately no such observable, much less measurable, indicator of discrimination exists in the broadband access market, and in particular there is no observable measure of non-price discrimination. This sub-section proposes two measures of non-price discrimination: first the ratio of unbundled local loops to all copper-based broadband access lines supplied by BT's competitors and, secondly, the location of the marginal exchange.

5.1.1   LLU as a Proportion of Competitive Copper Access

As has been explained above, LLU is considered superior to bitstream because it allows a greater degree of innovation by entrants and the ratio of fixed to variable costs allows the entrant to earn higher profits, or offer lower prices, once it obtains scale in each exchange. However, there are higher barriers to entry for LLU, due to the fixed costs and so the entrant would be less willing to enter via LLU if it considered the incumbent would discriminate against it. By contrast, bitstream does not allow innovation and has no economies of scale, but barriers to entry and exit are lower. The entrant also retains an option to upgrade to LLU if realising this option is expected to be more profitable.

The assumption, therefore, is that the entrant would always prefer LLU to bitstream provided that it can gain sufficient scale in each exchange area and

that there are no market distortions. This is because the entrant's average costs using bitstream are constant, whereas they are constantly falling if it can use LLU up to the capacity of their exchange-based equipment[61]. Once it achieves a certain scale, therefore, its average cost of LLU will be lower than for bitstream. LLU also provides the opportunity for the entrant to differentiate its service from that of the incumbent and its other rivals.

However, in the presence or expectation of discrimination, which raises the entrant's costs, it would be more likely to prefer bitstream. This is because discrimination can be considered a cost that raises the economic barrier to entry and would require the entrant to sell more lines to recover those fixed costs (Xiao and Orazem, 2011). If the entrant is uncertain as to whether those costs can be recovered, or indeed what the level of that cost might be, it could take the low risk option and not enter via LLU but remain with bitstream.

Entrants' decisions regarding which input product to use are observable in the whole geographic market by the number of LLU and bitstream lines. Therefore, *ceteris paribus,* the proportion of competitive copper access (CCA), i.e. copper broadband access lines provided by entrants only, accounted for by LLU is a measure of discrimination. The higher the ratio, the lower the level of discrimination and vice versa.

5.1.2 The Location of the Marginal Exchange

There are 5,581 telephone exchanges in the UK of varying sizes, measured by total premises connected to the exchange, and varying population densities. The total number of premises and the population density can be taken as proxies for the potential revenues and costs of entering the exchange. Thus these exchanges are heterogeneously profitable. An entrant must decide between three methods when choosing whether and how to enter the market: it could build its own network (facilities), enter via LLU or via bitstream (services). A fourth option would be not to enter the exchange area at all. In principle this decision could be made separately in each exchange area, i.e. it could choose its own infrastructure at exchange *i* and bitstream at exchange *j.* Ranking the exchange from the smallest as number 1 to the largest at 5,581, the marginal exchange is defined as the exchange at which the entrant is indifferent between one entry method and another.

In an undistorted market, a profit-maximising entrant would make the choice between facilities- or services-based entry on the basis of expected profits from each alternative. Baranes and Bourreau (2005) describe the decision between facilities-based entry and services-based entry formally as:

$$\pi^F - F \geq \pi^S(r) - f \qquad\qquad \textbf{(1)}$$

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[61] A firm entering the market via LLU has to place its own equipment in the local exchange to provide a broadband service. This exchange equipment has a maximum capacity of lines it can support and once that capacity is reached, further equipment needs to be installed.

Where π^F is the gross profit from facilities-based competition, F is the fixed cost of the facility, π^S is the gross profit from service competition, r is rental cost of the line and *f* is a fixed fee. Baranes and Bourreau assume that $\pi^S(r)$ is decreasing in *r*.

The concern of this thesis is the choice between forms of CCA, specifically between LLU and bitstream, as it was this form of entry that was the concern of Ofcom's regulatory changes in 2005.

A firm choosing some form of CCA will make the decision regarding which form of CCA at the telephone exchange area level. Generally speaking exchange areas that have more premises and are more densely populated will be unbundled (i.e. the entrant will buy LLU), whilst in exchange areas with fewer premises and that are less densely populated the entrant will be more likely to enter via bitstream access. This is because an entrant using LLU must invest in capital equipment to install at the exchange so that each unbundled line can be conditioned to carry a broadband signal. By contrast, bitstream entry has no capital cost, but a higher variable, per line, cost.[62]

Baranes and Bourreau's inequality can therefore be re-configured to illustrate the decision between LLU and BSA on an exchange-by-exchange basis, as

$$\pi_i^{LLU}(r^{LLU}) - F_i \geq \pi_i^{BSA}(r^{BSA}) - f_i^{BSA} \qquad (\,2\,)$$

The entrant will invest in LLU at exchange *i* when the profits from LLU given the rental cost of the unbundled local loop minus the fixed costs of LLU are greater than the profits less the variable costs of BSA. The marginal exchange, i.e. the exchange where the entrant is indifferent between LLU and BSA, is located where the inequality becomes an equality. As with equation (\,1\,), $\pi_i^{LLU}(r^{LLU})$ is decreasing in *r.*

The location of the marginal exchange may be affected by both static and dynamic considerations and by the entrant's experience of the market.

Statically, the marginal exchange would be located where the profits from LLU exceed the profits from BSA whilst the end product as used by the consumer remains unchanged. The entrant would base its decision on which exchanges to unbundle based on the total costs of BSA and LLU given the expected number of customers in the exchange area. The choice is based on the average cost of serving each customer dependent on the combination of fixed and variable costs for LLU and the variable costs of bitstream.

However, as discussed earlier, LLU provides the entrant with the opportunity to differentiate its product from competitors, including the incumbent. The entrant

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[62] This expectation was examined by Nardotto, Valletti and Verboven (2012) who found that "a sufficiently large market size is important to recover the fixed costs [of unbundling]." (Nardotto et al., 2012, p.16)

installs its own equipment in the exchange and so can control the bandwidth offer to the customer along with other quality metrics such as contention ratios[63]. Nardotto, Valletti and Verboven examined line speeds available in unbundled and non-unbundled exchanges. They conclude "Users who subscribed to an LLU operator have a connection speed that is about 18.6% higher than that provided by BT" (Nardotto et al., 2012, p. 24).

Nardotto et al's finding is supported by Figure 18, which shows the correlation between the diffusion of LLU as a proportion of CCA and the average broadband speed in the UK (Cadman, 2015, p. 199).

An Internet Service Provider (ISP) entering via LLU, at least in some exchanges, is therefore likely to consider the higher profits it might earn from providing a better service to customers than it could do if it was basing its service on BSA or RA.

Finally, entrants learn about the market as they gain experience. They may begin with one view of the location of the marginal exchange, but adapt that view over time, potentially in both directions, as they learn more about their costs and revenues. In other words, they do not begin the process of investment with perfect foresight of either their costs or market potential and will adjust their investment decisions as they learn more.

Figure 18: Relationship between LLU:CCA and Access Speed in UK
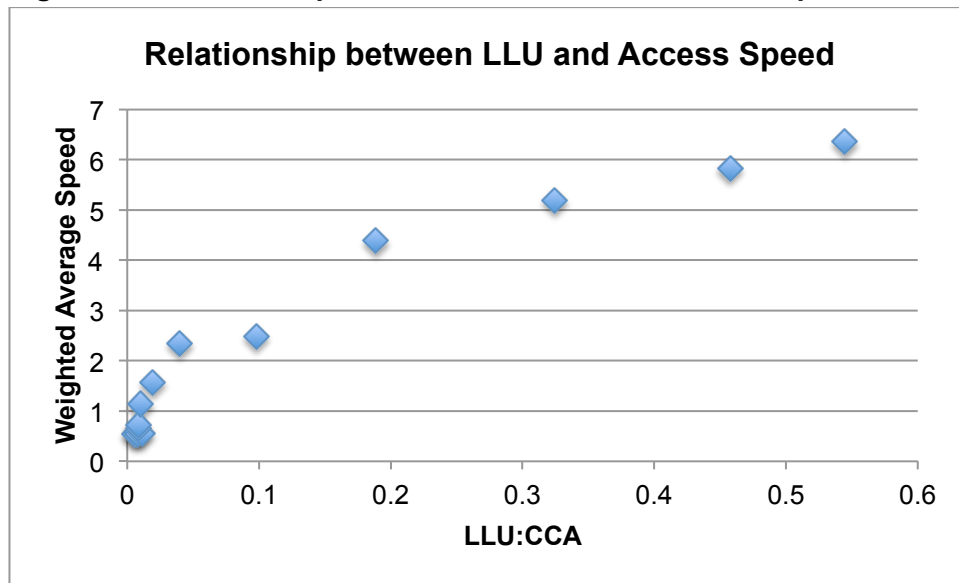
Entrants' choice of LLU versus bitstream may also be affected by the expectation of strategic behaviour by the incumbent operator, in particular attempts to discriminate. Just as the entrant learns about the market with experience, the incumbent also learns how the market responds to competition and may change

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[63] The proportion of total customers that can access the service at the same time. Broadband providers would normally assume that not all customers are on-line simultaneously and so design their networks to support only a proportion of total customers.

its strategic choices with that learning. The costs of strategic behaviour can be considered as "sunk costs" in that they cannot be recovered in the event of exit from the market by the entrant (Xiao and Orazem, 2011).

Although the incumbent may have the ability and incentive to discriminate against entrants on all CCA platforms, the cost of discrimination for the entrant on LLU would be greater than on BSA. This would be the case because the entrant faces higher barriers to entry when using LLU: it has to invest in its own capital equipment at the exchange and therefore needs to obtain a minimum level of subscribers per exchange at the market price to recover its investment. Any discrimination that made it more difficult to compete against the incumbent would therefore have a more detrimental effect and could leave the entrant with assets on which it cannot make a reasonable return.

If this is the case, then Baranes and Bourreau's inequality can be adapted still further to incorporate the cost of discrimination (D) as shown below.

$$\pi_i^{LLU}(r^{LLU}) - (F_i + D^{LLU}) \geq \pi_i^{BSA}(r^{BAS}) - (f_i^{BSA} + D^{BSA}) \qquad \textbf{(3)}$$

The effect of D would be to raise the overall costs of each of LLU and BSA but to leave the breakeven quantity the same. The fixed costs of market entry are economic barriers to entry[64], whereas D is an antitrust barrier to entry, defined as "a cost that delays entry and thereby reduces social welfare relative to immediate but equally costly entry" (McAfee et al., 2004, p. 463). It should also be noted that f_i^{BSA} could be zero, if there are no fixed costs of BSA, as is the case later in this chapter.

Referring back to Figure 3 from Scheffman (1992), D is the amount by which marginal producers' costs are raised by the strategic behaviour of the dominant infra-marginal firm to reduce the number of exchanges the rival enters rather than the quantity it produces. In the language of Arrow, it is the difference between the wages of white and black steel workers for reasons other than productivity.

The incumbent could discriminate more aggressively against competitors it regards as strong and less aggressively against weaker competitors, thus raising the costs of strong entrants by more than those of weak entrants. Whilst this possibility is recognised, it is not explored empirically in this thesis due to the terms on which data have been provided by firms in the market, which require the data to be aggregated.

Two hypotheses follow from the preceding analysis:

Hypothesis 1: The proportion of CCA accounted by LLU is a measure of the effectiveness of non-discrimination policies by the regulator: the higher the proportion the more effective the regulator at deterring discrimination. The 2005

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[64] Defined in McAfee et al. (2004) as "a cost that must be incurred by a new entrant and that incumbents do not or have not had to incur" (p. 463).

reforms led to an increase in the ratio of LLU:CCA. This hypothesis assumes that the wholesale price and quality of BSA remain constant.

Hypothesis 2: The location of the marginal exchange for entry by LLU, measured by characteristics of the area that is likely to make the exchange more profitable, is an indicator of the entrant's expected costs of discrimination. The size of the marginal exchange, measured by the number of premises in the exchange area, will have become smaller following the 2005 reforms.

5.2   LLU as a Proportion of CCA

This subsection examines hypothesis 1: that the 2005 reforms caused an increase in the ratio of LLU:CCA. Figure 19 plots the diffusion of LLU:CCA (right hand scale) and the development of LLU prices (left hand scale) over the period 2003 – 2010 in the UK. The vertical line marks the point at which the Undertakings were agreed between BT and Ofcom.

This chart strongly suggests that ISPs responded to the price cut and the Undertakings by increasing their use of LLU to service broadband customers, replacing their bitstream connections. However, in itself it does not prove a causal relationship and it also raises the question of whether ISPs were responding to the price cut or the Undertakings, or both.

Figure 19: LLU Price, Undertakings and Diffusion
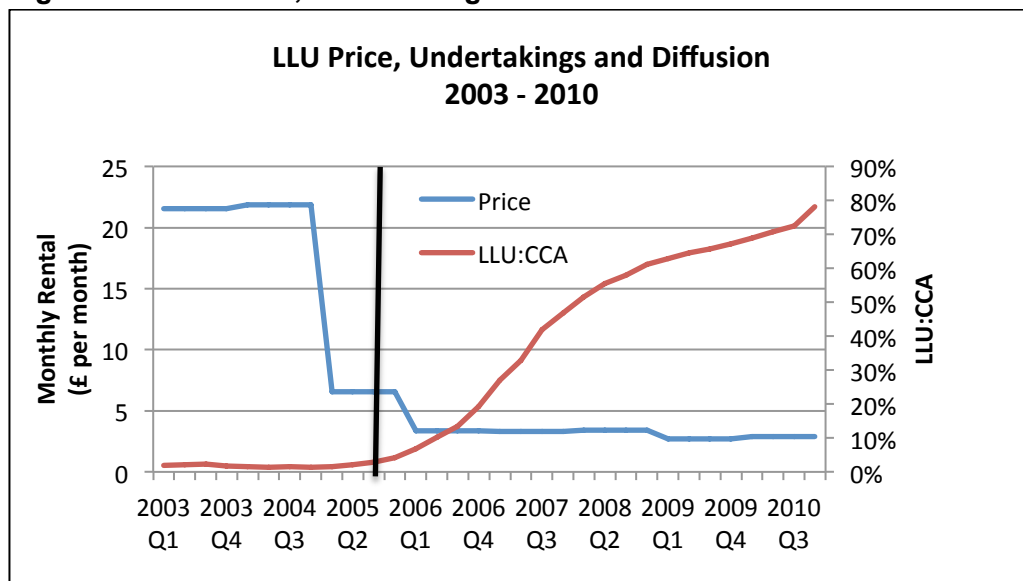
It is also clear from the chart that the rate of change of LLU:CCA follows a form of S-shaped diffusion. To attempt to assess whether the development of LLU:CCA resulted from Ofcom's interventions, this thesis now adopts the relatively new approach of induced diffusion to assess whether Ofcom's actions affected the rate of diffusion. An alternative explanation for the growth of LLU will be considered in 5.2.2.

5.2.1 Diffusion and Induced Diffusion of Innovations

The diffusion of innovations has been widely studied (Griliches, 1957; Rogers, 1962; Bass, 1969; and Davies, 1979). The essence of diffusion is that an innovation is adopted by a market at a rate proportionate to the existing number of users and the maximum number of potential adopters of the technology. It can be simply expressed as:

$$Pen_t = \frac{Pen^*}{1 + e^{(-(a_t + b_t t))}}$$

Where Pen_t is the penetration of an innovation at time *t* and Pen* is the ceiling or equilibrium penetration of the innovation. The coefficient *a* shifts the diffusion curve forwards or backwards without changing its shape and *b* is the rate of change of the slope at a given time.

Geroski (2000) provides a particularly useful review of the literature and refers to four types of diffusion model: epidemic, probit, legitimation and competition, and information cascades.

The basic premise of the epidemic model, the type most appropriate to this thesis, is that information diffusion drives technology diffusion. A small group of early adopters of a new technology acquire their information from a central source before experience and knowledge of the new technology spreads through the rest of potential user population (imitators). At first there is a small proportion of the population who adopt the new technology but the number of users increases rapidly until information is nearly universal, at which point further adoption slows. This pattern of knowledge diffusion leads to the 'S' shaped curve.

In the epidemic model, Geroski, like Davies (1979), identifies two diffusion functions: type A and type B (Figure 20)[65]. In the type A function, information about the innovation is spread from a central source reaching α % of the population of non-users in any time period. The smaller the value of α, the slower the rate of diffusion and therefore the longer the time period needed for the innovation to be widely adopted.

Type B diffusion relies on some form of information dissemination amongst potential users, e.g. word of mouth. Each existing user independently contacts a non-user with a probability β. It is this spread of knowledge that leads to the 'S' shaped curve. However, Geroski points out a serious weakness of this model: it cannot explain the diffusion of an innovation from the date it is invented, only from the date that the first users have adopted the innovation.

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[65] Later in this paper we will see that broadband appears to have been adopted at rates that match both type A and type B diffusion.

Figure 20: Type A and Type B Diffusion Curves
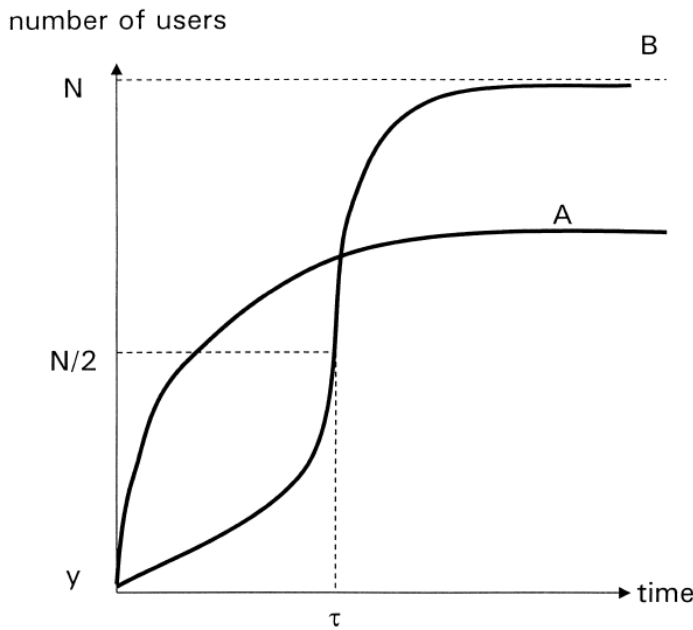
A particularly well-known epidemic model was developed by Bass (1969). He identifies a "coefficient of innovation" and a "coefficient of imitation". Innovators, in Bass's terminology, are purchasers who are not influenced in the timing of their purchasing decision by the number of people who have already bought the product. Imitators, in contrast, are influenced and so "learn' from those who have already purchased. His basic model is:

$$S(T) = pm + (q - p)Y(T) - \frac{q}{m}Y^2(T)$$

Where S = sales, T = Time, p = the coefficient of innovation, q = the coefficient of imitation, Y = total sales and m = is the total number purchasing during the period for which the density function was constructed. To estimate the parameters, Bass employs the analogue:

$$S_T = a + bY_{t-1} + cY^2_{t-1}$$

Where S_t = cumulative sales at T and Y_{t-1} = cumulative sales through period T-1.

The theory of diffusion has been taken forward by the study of "induced diffusion" (Jaffe, Newell and Stavins, 2002). The principle behind induced diffusion is that policy makers wish to see either a higher ceiling, or equilibrium level, of adoption of a technology or a more rapid take-up of that technology. Diaz-Rainey defines induced diffusion as:

> *"Any intervention that aims to alter the speed and/or total level of adoption of an innovation by directly or indirectly internalising positive and/or negative externalities."* (Diaz-Rainey, 2009, p. 6)

Interventions aimed at inducing diffusion are usually mandated, or at least inspired, by government or independent regulators. Such interventions are aimed at changing individuals' and businesses' choices by altering the economic attractiveness of one option over another (Diaz-Rainey, 2009).

Induced diffusion has particularly been widely researched in the energy sector where governments have sought to promote environmentally "friendly" technologies, such as wind energy. Davies and Diaz-Rainey (2011) empirically examine induced diffusion of wind energy in the OECD countries. They use both the logistic and Bass forms of diffusion to determine whether there has been a policy effect on the take up of wind energy using equations 4 and 5 for the logistic and Bass curves respectively.

$$\frac{\{P(t+1) - P(t)\}}{\{1 - P(t)\}} = bP(t) \qquad\qquad (\,4\,)$$

$$\frac{\{P(t+1) - P(t)\}}{\{1 - P(t)\}} = a + bP(t) \qquad\qquad (\,5\,)$$

The parameter *a* captures external effects In the Bass equation, and the logistic curve is a special case of the Bass curve where *a* = 0. The parameter *P(t)* is the proportionate percentage penetrate/diffusion relative to some saturation level. The constant 1 suggests that the saturation level is 100%, although a lower saturation level is used in the empirical part of their paper.

Davies and Diaz-Rainey set out four propositions, the first and third of which are relevant to this thesis:

> "**Proposition 1:** *Wind energy is a complex and expensive technology that* ceteris paribus *should display a Type B diffusion curve, i.e. symmetric S-shaped, as described by the logistic or cumulative normal curve.*

> "**Proposition 3:** *Induced diffusion may alter the exogenous process so as to give rise to an asymmetric diffusion curve, better described by the Bass model than by the symmetric logistic curve.*" (Davies and Diaz-Rainey, 2011, p. 1231)

If proposition 1 were to hold then a = 0 and if proposition 3 holds than a > 0. They find that in all but four countries (Germany, Ireland, Spain and Sweden) *a* is not significantly different, at 10%, to 0 and so induced diffusion only occurs in these four countries.

Propositions 1 and 3 have been tested for the LLU:CCA ratio using the econometric model employed by Davies and Diaz-Rainey by fitting the logistic and Bass models in their first difference form to the data, using the equation:

$$Switch(t) = a + bP(t) \qquad\qquad (\,6\,)$$

where

$$Switch = \frac{[P(t+1) - P(t)]}{[0.9 - P(t)]}$$

Where *Switch(t)* is the proportion of CCA that is switched from bitstream to LLU during time period *t*.

The assumed saturation level for LLU:CCA has been set at 90%. This is because it is unlikely that competitors would enter all exchanges in the UK using LLU and so there is always likely to be a residual level of BSA. However, the model has been tested using other levels of saturation without any significant difference to the outcome.

The result of the equation is shown below, with P values below.

$$Switch = 0.02 + \ \ 0.15P$$
$$(0.27) \quad (0.00)$$

The first point to note is that the *a* is not significantly different from 0. Following Davies and Diaz-Rainey's propositions 1 and 3, this suggests that the logistic diffusion curve is a better fit and that the diffusion of LLU:CCA was not induced. That is to say that the policies did not affect either the rate of diffusion or the equilibrium level. However, as is clear from Figure 19, LLU did not begin to be used as an alternative to bitstream until 2005, five years after it was first made available, and at the time that Ofcom made regulatory and pricing changes.

The coefficient b represents the speed of diffusion and is estimated as 0.15, which is similar to that estimated by Davies and Diaz-Rainey in their fixed effects model (0.186) and which they describe as "fairly typical of this type of international diffusion study" (Davies and Diaz-Rainey, 2011, p. 1234).

However, it should be noted that the R^2 for this model is not particularly strong at 0.42. Full results from Stata 13 are shown below in Annex A, including at different levels of saturation.

Given the intuitive interpretation of Figure 19, that the Undertakings and price cut affected the initial diffusion of LLU, it would be helpful to find another approach that could determine whether this was indeed the case. An approach would be to adopt the model used by Gruber and Verboven (2001) in their study of diffusion of mobile telecommunications in Europe. They use the basic logistic function and specify *a* as the timing variable, which is calculated as follows:

$$a_{it} = \alpha_i^F + \alpha^D DIG_{it} \qquad\qquad \textbf{(7)}$$

where DIG is a dummy variable indicating whether or not digital technology had been introduced at time *t*. The α_i^F are fixed effects for each country *i,* and capture

an adoption lag or lead relative to a base country. In principle a similar equation could be used to calculate the lag or lead caused by Ofcom's regulatory changes replacing the dummy variable DIG with one indicating the timing of the Undertakings and price cut. However, these were not changes that were introduced in any other European country, in the same way that digital mobile technology was introduced. Further, data on the number of LLU lines are not available on a consistent basis. It is necessary therefore to draw the intuitive conclusion from Figure 19 that Ofcom's changes had an effect on the timing of the diffusion of LLU even though that effect cannot be quantified.

Diffusion models appear not to help identify whether there was a causal link between Ofcom's actions and the increase in the rate of LLU:CCA, either within the UK or on a comparative basis. Nor do they help identify whether it was the effect of the Undertakings or the price cut that resulted in an increase in LLU:CCA. The section below adopts a different approach of using a breakeven analysis to locate the marginal exchange in a further attempt to measure the effect of the regulatory changes.

5.2.2   An Alternative Explanation

This section briefly considers an alternative explanation for the growth of LLU after 2005: that the increase in LLU:CCA followed naturally from the development of the retail broadband market. This alternative would suggest that ISPs switched from BSA to LLU as they became more confident in the level of demand for broadband at the retail level.

This suggestion would be supported by an "Austrian" view of entrepreneurial discovery, i.e. that entrepreneurs do not have perfect knowledge at the start of a market's development but learn about demand and supply conditions as they gain experience of the market. In this case, as demand and cost conditions become clearer so entrepreneurs are better able to make decisions between market entry options. Thus, in the early stages of the market, ISPs maintained an open option by not committing to LLU and only changed to LLU once they felt confident they would be able to recover the fixed costs of entry via LLU.

Whilst such a view cannot be entirely discounted, it is rejected in this thesis for two reasons. The first is suggested by Figure 19: the diffusion of LLU:CCA only properly began after the price cut and the implementation of the Undertakings. It would be an unlikely coincidence if entrepreneurs decided to switch to LLU at this time and did so without reference to the regulatory changes introduced at the same time.

The second reason is suggested by the comparison with France later in this thesis in Section 5.4 and in particular in Figure 28 which shows that the LLU:CCA ratio increased much earlier in France that in the UK, despite LLU becoming available about six month later in France. Although not shown in any Figure, it is also the case that the diffusion rate of retail broadband was almost exactly the same in the two countries.

Other than the concerns about BT's potential behaviour and the regulatory changes introduced by Ofcom there seems to reason to expect that entrepreneurs in France would discover LLU any earlier than their UK equivalents.

5.3 Locating the Marginal Exchange: A Breakeven Analysis

5.3.1 Introduction

Firms entering the broadband market via LLU do so at each exchange and each exchange can be considered a discrete local (geographic) market. Using the normal Hypothetical Monopolist Test (HMT), a user in one exchange area could not substitute a line in that area with one connected to another exchange in the event of a SSNIP. A hypothetical monopolist could therefore impose a SSNIP profitably as there could be no demand side substitutability. Similarly, there is no supply-side substitutability as a firm in one exchange area could not enter another area using existing assets.

Two factors are likely to affect the choice of exchanges a firm enters via LLU: the expected profits and the likely strategic response of its rivals and, in particular, of any firm that is already in that local market. In the UK, BT is the incumbent operator in all local exchange markets. The decision to enter an exchange can therefore be examined using a variation of a classic game of market entry and deterrence and the location of the marginal exchange can be established by observing how many exchanges (markets) it enters. How much the incumbent is able to raise the costs of rivals can be established by observing the difference between the number of exchanges that would be entered if there were no actual or expected discrimination and the number actually entered.

One approach to locating the marginal exchange would be to use a classic game of entry deterrence played at each of the 5,581 exchanges treating each as a discrete local market.

Such a game is explained in Dobbs (2000, Section 14-4.2), in which an entrant must decide whether to enter a market or stay out in the face of some commitment by the incumbent to signal that it will fight entry. The choice of the incumbent to fight entry may be taken ignoring the threat of entry but still affecting the entrant's decision ('blockaded entry") or taking account of probable entry ("deterred entry"). Whether entry is blockaded or deterred does not affect the game, in part, at least, because the entrant only observes the action of the incumbent and does not see its reasoning.

In the simplest form of the game, where the incumbent firm does not attempt to block entry, the entrant chooses to enter or not, and, in the event of entry, the incumbent chooses to accommodate the entrant or fight it. There are three pairs of pay-offs (incumbent first):

a) π_m, 0 – the entrant remains out of the market, leaving monopoly profits to the incumbent whilst the entrant receives nothing;

b) π_s, π_s – both receive equal profits of about π_s;

c) π_f, π_f – both receive equal profits of π_f and where $\pi_f < \pi_s$

The subscripts s, and f refer to sharing the market and fighting.

Where the incumbent deters entry (deliberately or otherwise), in Dobbs' example by expanding capacity, it incurs cost C > 0, but, through its strategic behaviour, adds to its profits an amount D_i whilst the entrant's profits are reduced by D_e[66]. The pay-off to both parties (incumbent first) if the incumbent commits and fights the entrant is:

$$\pi_i + D_i - C; \pi_e - D_e$$

In a normal analysis the game is played once, that is to say there is a single market where entry may take place, which would happen if the pay-off for the entrant is positive, i.e. $\pi_e - D_e > 0$. In the UK broadband market, however, the game would be repeated at each of the 5,581 exchanges and entry would incur only in exchanges where the entrant expects to earn a profit. The marginal exchange would be defined as the exchange where $\pi_e - D_e = 0$.

A complicating feature of such a game in regulated markets is that both the incumbent and entrant would need to take a view on the strength of the regulator and its ability to prevent or deter strategic behaviour by the incumbent. The regulated incumbent may be more willing to accommodate entry if it decided that the regulator could punish exclusionary behaviour on its part. Likewise the entrant's decision to enter or stay out is likely to be affected by its view of the strength of the regulator.

To establish the amount by which entrants perceived their costs to have been raised by BT's potential strategic behaviour (the parameter D in the game), this thesis now employs a breakeven analysis before and after the price cut and Undertakings and therefore to locate the marginal exchange.

5.3.2 Data

To establish the location of the marginal exchange, before and after Ofcom strengthened the regulation, this thesis employs a breakeven analysis. Data for the empirical analysis have been obtained from a number of public and private sources. Table 6 shows summary statistics for the variables together with the source. Data marked with an asterix (*) have been provided on a confidential basis on condition that any presentation of the data does not reveal to which company the data belong.

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[66] It is not clear from Dobbs whether $D_i - D_e = 0$, i.e. there is a transfer of profit from the entrant to the incumbent, or whether D_i and D_e are independent.

Variable	Variable Name	Obs	Mean	Std. Dev.	Source/Comments
Exchange Code	ExchangeCode	0			
Exchange Name	ExchangeName	0			
Total Premises	TotPrem	5580	4,937	7,206	Samknows.com
Population Density (persons per sq. km.)	PopDensity	5562	10.5	21.8	UK government data based on local government ward of exchange postcode.
Median Income	Median_Income	5580	30,134	9,769	CACI
Northern Ireland	NI	5580	.03	.18	Whether exchange in Northern Ireland
Scotland	SC	5580			Whether the exchange is in Scotland
Wales	WA	5580			Whether the exchange is in Wales

Table 6: Data and sources

Data on the exchanges that have been unbundled and the year of unbundling have been provided on a confidential basis by Sky and TalkTalk. To respect their confidentiality the data for the two companies have been combined to form a single variable "Unbundled" indicating an exchange that has been unbundled by at least one of these two companies. Where one company has unbundled an individual exchange before the other the earlier of the two dates has been used. Data on the exchanges covered by Virgin Media and where BT has installed FTTX have been obtained from www.samknows.com.

The smallest exchange area (Papa Stour in the Shetland Isles) has just 12 premises connected and a population density of 0.08 people by square kilometre. At the other extreme, Oldham (Lancs.) has 64,500 premises and a population density of 58 persons per square kilometre. Summary statistics are shown in Table 7 below. However, the mean values do not tell the whole story as both Total Premises and Population Density are strongly and positively "skewed"[67], as is shown in the left hand and right hand sides of Figure 21 respectively. Over 50% of exchange areas have fewer than 500 premises and over 70% have a population density of less than 10 persons per square kilometre.

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[67] Skewness is a measure of the asymmetry of the distribution of a variable about its mean.

Variable	Observations	Mean	Std. Dev.	Min	Max	Skewness
Total Premises	5,580	4,937	7,206	12	64,501	2.3
Population Density	5,562*	10.5	21.8	0.08	215.4	3.8
Median Income	5,580	30,134	9,770	7,300	76,600	0.6

* It was not possible to establish the population density for 12 exchanges (0.2% of all exchanges).

Table 7: Summary Statistics of Telephone Exchange Areas

Figure 21: Distribution of Demographics of Exchange Areas
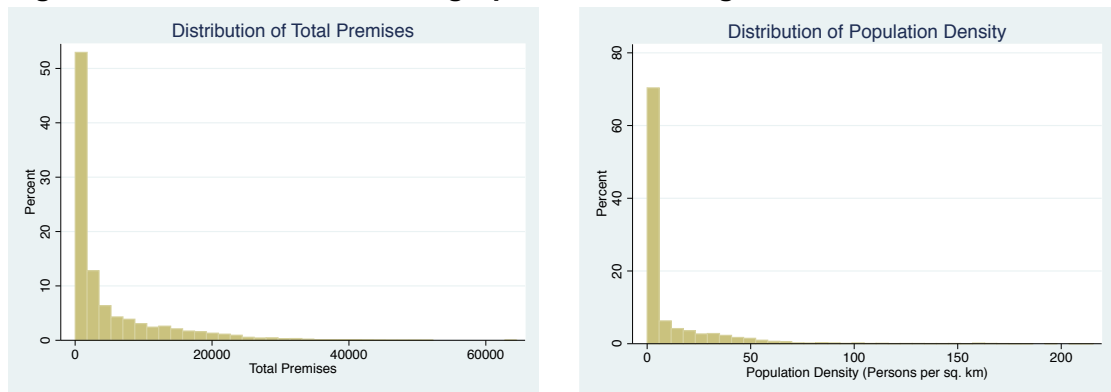
The total number of premises in an exchange area can be taken as a proxy for the potential revenue in that exchange: the higher the number of premises, the greater the market potential. The population density can be taken as a proxy for costs: higher population density would mean that each premises has a lower cost of supply. Thus an exchange area with a high number of premises and a high population density is likely to be more profitable than one with a small number of premises and a low population density, as illustrated in Figure 22. However, whilst the effect of the total premises can be estimated in the breakeven analysis that follows, as the proportion of premises ISPs need to earn a profit, the effect of population density is unknown. A more densely populated exchange area may have lower costs, but the relationship between density and costs is not known. The population density has therefore been excluded from the breakeven model. It is also the case that population density and total premises are strongly correlated.

Figure 22: Profitability of Exchange Areas
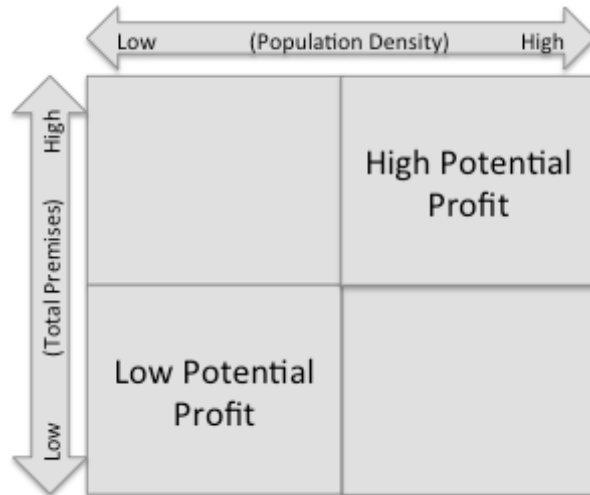
Unbundling of telephone exchanges in the UK began in 2003, although BT first offered LLU in December 2000. Figure 23 plots the number of exchanges unbundled per annum (left hand scale) along with the cumulative number of unbundled exchanges (right hand scale). The chart clearly shows that very few, a total of 231 (about 4%), exchanges were unbundled before the Undertakings were signed and that no exchanges were unbundled in 2005. Then, in 2006 and 2007, 1,367 exchanges were unbundled by Sky, TalkTalk or both (or companies they subsequently acquired). So exactly half of the total number of exchanges unbundled by the end of 2012 were unbundled in the two years immediately after the signing of the Undertakings and the implementation of the price cut. The reason why so few exchanges were unbundled in 2008 and 2009 is not known. However, informal discussions with Sky and TalkTalk suggest that the pause was to allow them time to migrate customers from bitstream to LLU in the exchanges where they had invested in LLU.

Figure 23: Unbundled Exchanges
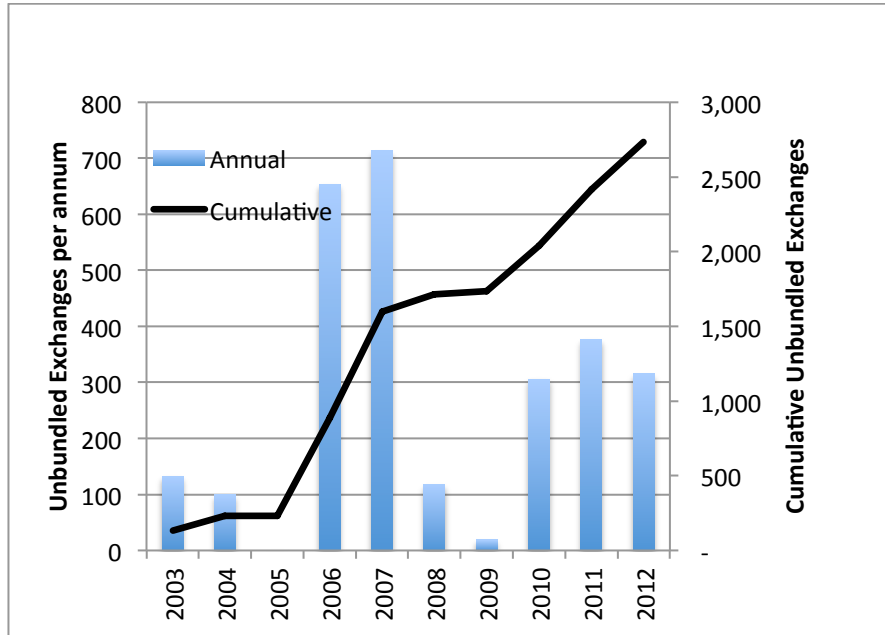
Table 9 below, provides further information on the demographics of the exchanges unbundled in each year.

Year	Exchanges	Mean Total Premises	Population Density	Median Income
2003	132	19,452	75.1	35,486
2004	99	23,553	51.5	29,174
2005	0	-	-	-
2006	654	15,329	31.8	30,503
2007	713	9,071	18.3	29,057
2008	118	5,859	9.9	29,878
2009	19	11,369	15.0	26,705
2010	306	4,221	7.4	29,284
2011	377	3,011	4.4	30,453
2012	315	2,126	3.0	31,106

Table 8: Unbundled Local Exchanges 2003 - 2012

Some points are immediately apparent from these data:

1)   As may be expected, over time the average size of the exchange area, counted as total premises in the area, declined, as did the population density as unbundlers extended their reach from larger urban exchanges to smaller rural ones.

2)   The exceptions to the above were 2004 and 2009 when mean size increased. In 2004 the mean size may have increased as unbundlers became more experienced about which exchanges to enter. In 2009 this was probably due to the small number of unbundled exchanges.

3)   Similarly, in 2003, the median income in the exchange areas unbundled was around £5,000pa more than in any other year. In all other years, the median income shows very little variation.

4)   No exchanges were unbundled in 2005 and very few in 2009. There are two potential reasons why no exchanges were unbundled in 2005. Either ISPs were so badly affected by BT's perceived strategic behaviour that they decided not to invest further, or they were waiting for the outcome of the TSR before making further investment decisions. The lower number of exchanges unbundled in 2008 and 2009 was discussed above.

Figure 24 shows the total number of premises in the unbundled exchange areas as a proportion of all premises. The figure shows how the period covered can be divided into three sections:

- Before 2006, when the 231 unbundled exchanges covered approx. 18% of all premises;
- The rapid growth between 2006 and 2007 when a further 1,367 exchanges were unbundled covering an additional 59 percentage points of the population; and
- A period of much slower growth since 2008 when the additional 1,135 exchanges extended the reach of unbundlers by 15 percentage points to 92% of the total premises.

Figure 24: Cumulative Unbundled Exchanges as Proportion of all customer premises
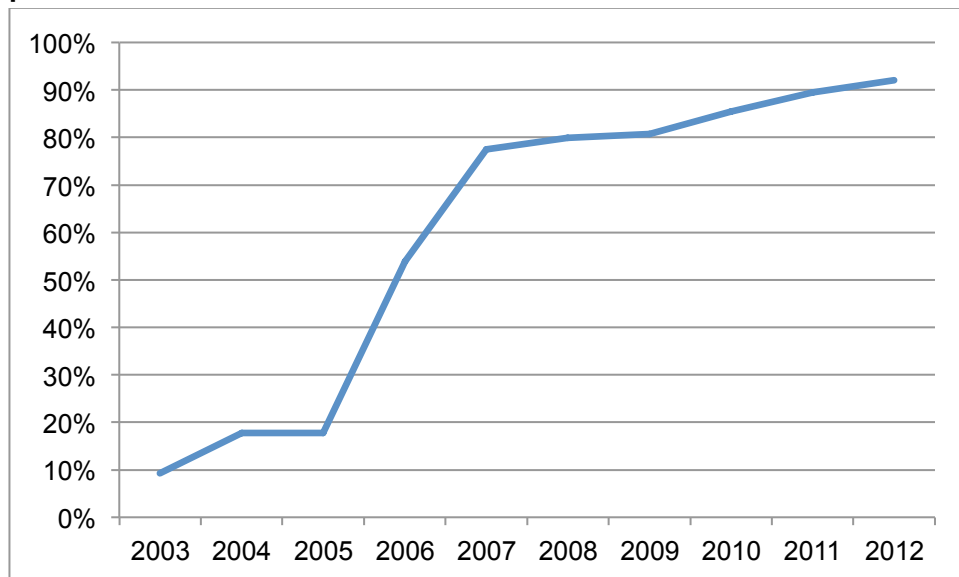
The period of interest in this thesis is around 2005, when unbundlers' attitudes changed such that they became prepared to invest in entering exchanges beyond the initial 230 or so and extend their network to nearly 80% of all customer premises.

The Undertakings agreed between BT and Ofcom in 2005 were designed to improve the conditions of entry for competitive operators through a specifically *ex ante* form of non-discrimination known as Equivalence of Input. Their objective was to remove competitors' fear that BT could foreclose the market to them should they chose to enter an exchange on the basis of LLU. *Prima facie*, the data in Figure 23 and Figure 24 suggest that the Undertakings and price cuts were successful in increasing the number of exchanges in which LLU was the principal form of CCA to rival BT. However, what this thesis is trying to establish is the relative effect of the price cut and Undertakings. In other words, was the price cut more important than the Undertakings or vice versa?

5.3.3   The Effect of the Price Cut on the Location of the Marginal Exchange

The location of the marginal exchange before and after the price reduction can be established by undertaking a breakeven analysis to locate the exchange where the profits from entry via LLU are the same as those via bitstream, excluding any costs of discrimination. To know a firm's profits one of course needs to know both revenues and costs. Whilst cost data are available, revenue data are not but at the time broadband service providers had a national pricing policy such that consumers accessing via LLU or bitstream paid the same price regardless of their geographic location[68]. Thus the breakeven analysis can be run just using costs.

$$SC_{LLU} + qc_{LLU} = qc_{BSA} \qquad (8)$$

Where SC_{LLU}^i are the fixed cost of entry via LLU at exchange i, c_{LLU} are the variable costs of LLU and c_{BA} are the variable costs of bitstream. The fixed, sunk, cost of LLU entry and the costs of bitstream do not change between the periods, so to establish the breakeven costs at *t* and *t+1* only c_{LLU} changes.

To estimate the cost of discrimination the sunk costs can be separated into a normal fixed cost of entry *(F)* and the cost of discrimination (*D*), where *D* only applies to entry via LLU:

$$F_{LLU}^i + D_{LLU}^i + qc_{LLU} = qc_{BSA} \qquad (9)$$

Rearranging this to estimate the bearable cost of discrimination at an exchange yields:

$$D_{LLU}^i = q(c_{BS} - c_{LLU}) - F_{LLU}^i \qquad (10)$$

The variable *D*[i] simply becomes the difference between the total costs of LLU and bitstream for a given number of lines in each exchange and is thus the amount by which the incumbent could raise its rival's costs allowing the rival to

[68] Some operators later changed this and charged a premium in areas where they had not entered via LLU.

breakeven at exchange *i*. To estimate a value for D^i it is necessary to make a judgement about the number of lines in the marginal exchange before the Undertakings were signed and implemented. This will be done later in the Chapter by examining the number and characteristics of those exchanges that were unbundled before the Undertakings were signed.

As BT was, and indeed is, the dominant provider of unbundled local loops to third parties, Ofcom has direct control of the prices BT may charge for LLU. In 2005, Ofcom substantially reduced the regulated price of LLU. Table 9 shows how significant that cut was, absolutely and in comparison with the other four largest member states of the EU.

		France	Germany	Italy	Spain	UK	Average
October 2003	**Full LLU**	17.10	16.50	11.00	14.00	25.50	16.22
	Shared Access	9.42	11.01	6.51	5.74	22.59	11.05
October 2005	**Full LLU**	10.90	11.80	9.30	12.00	11.20	11.04
	Shared Access	4.39	3.74	4.14	3.84	3.34	3.89

(European Commission Implementation Reports)

Table 9: LLU Prices (€), EU5, 2003 and 2005

Before the price cut, the UK had LLU prices around 50% higher than the next most expensive EU5 country and more than twice the price of the cheapest. After Ofcom cut BT's prices, the UK charged around the average price for the EU5, following a cut of 56% in Full LLU prices and a massive 85% price cut for shared LLU. Other countries also cut LLU prices, but by nothing like the same proportions.

Firms are generally cautious about providing information on the cost of unbundling an individual exchange. However, in 2006 Opal Networks/Carphone Warehouse published a report on the economics of LLU (Opal/CPW, 2006)[69]. This report identified the variable costs of LLU and BSA as shown in Table 10.

In addition, the unbundler needs to install a Multi-Service Access Node (MSAN)[70] at each exchange to convert the copper access line from a "dumb" piece of wire into a broadband line. Opal/CPW identify the capital cost (capex) of an MSAN as £40,000 for the first 500 lines per exchange and an incremental cost of £20,000 for the next 500 lines. These prices have probably come down since 2006, but are used here as that is the relevant period. Opal/CPW did not provide any information in their report about the depreciation period of the MSAN and TalkTalk Group's annual reports only refer to a depreciation policy ranging

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[69] At the time Opal was the network division of CPW. The broadband division of CPW has since been separated from CPW and is now named TalkTalk Group Ltd. It is the fourth largest of the four main broadband ISPs in the UK.

[70] An MSAN is an integrated broadband system delivering voice, video and data services to business and residential users. MSAN line cards provide connectivity to broadband customer premises equipment (CPE), aggregating DSL and Passive Optical Network (PON) traffic in a single design.

between 12.5% and 50%. The breakeven analysis assumes a depreciation rate of 20% per annum.

Monthly (£)	Wholesale Line Rental + IPStream	Metallic Path Facility[71]	Metallic Path Facility
Customers/exchange	N/A	250	500
Monthly Rental per line	16.40	6.70	6.70
Other Opex	2.50	4.50	3.00
Total cash costs	18.90	11.20	9.70

Table 10: Variable costs of LLU and BSA

The number of premises and the likely share of such that an ISP can gain are major determinants in whether it will enter an exchange area or not. The calculation of a breakeven point, i.e. where the ISP is indifferent between entry via LLU and entry via BSA is, in part therefore, a function of its expected share of exchange lines. At the time of the Undertakings, total household penetration of broadband in the UK stood at approximately 32% and independent ISPs (i.e. neither BT nor cable companies) had an average penetration rate of less than 5% of households. For the breakeven analysis this rate of penetration has been assumed to be the minimum rate that and individual firm would want to achieve and is therefore used as the central estimate. Results have also been calculated using 4% and 6% penetration level and are shown in Table 12.

Equation (8) is used to calculate the breakeven point.

Breakeven occurs where the fixed costs of LLU at exchange i plus the variable costs times the number of unbundled lines equals the variable costs of bitstream access times the number of lines. The fixed cost of entry at each exchange is the cost of the MSAN or MSANs dependent on the number of lines represented by a 5% share in the exchange area. The variable costs of LLU include the rental of the line from BT plus other operating costs as identified by Opal/CPW. The entrant is assumed to use BT's MPF (fully unbundled local loop product). The variable cost of bitstream also includes the cost of Wholesale Line Rental (WLR) to provide voice telephony services and other operating costs identified by Opal/CPW. The costs used in the breakeven calculation are shown in Table 11. All figures used in the calculation are sourced from Opal/CPW (2006).

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[71] Metallic Path Facility (MPF) is the technical name for a fully unbundled local loop. MPF provides the CP with both the high and low frequency bands on the copper line allowing the CP to offer both voice and broadband. Shared MPF (SMPF) provides only the low frequency band, which carries the broadband signal.

Fixed Costs	Cost (£)
Capex 1st 500 lines per exchange	40,000
Capex each additional 500 lines	20,000
Annual depreciation	20%
Variable Costs	
MPF Initial Fee – Pre-discount	88.03
MPF Monthly Rental – Pre-discount	10.15
Total Monthly Charge MPF Pre-Discount	15.60
MPF Initial Fee – Post-discount	45.53
MPF Monthly Rental – Post-discount	6.99
Total Monthly Charge MPF Post-Discount	11.25
Other Opex LLU	4.50 - 3.00[72]
Assumed contract period (months)	36
Bitstream + WLR	16.40
Other Opex Bitstream	2.50
Total Cost Bitstream + WLR	18.90
Share of lines in exchange	5%

Table 11: Break Even Analysis Data

The total monthly charge for LLU pre- and post-discount is calculated as:

$$\frac{MPF\ Initial\ Fee}{Assumed\ contract\ period} + MPF\ Monthly\ Rental + Other\ Opex\ LLU$$

As most exchanges are small, the lower end of the "Other Opex LLU" costs has been used. Thus the Total Monthly MPF Pre-Discount cost is:

$$\frac{88.03}{36} + 10.15 + 3.00 = 15.60$$

and the Total Monthly MPF Post-Discount is

$$\frac{45.53}{36} + 6.99 + 3.00 = 11.25^{73}$$

As the number of lines in each exchange area is known, and an assumption about the proportion of lines that an entrant would have targeted at the time of the Undertakings can be made, it is possible to calculate the breakeven quantity for each exchange by rearranging the equation as shown below:

$$SC_{LLU}^{i} = q(c_{BSA} - c_{LLU}) \qquad\qquad \textbf{(11)}$$

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[72] Depending on the number of lines.

[73] The totals shown are different from those reported in Table 9 due to a different calculation methodology used by the European Commission and the currency used.

$$\frac{SC_{LLU}^i}{c_{BA} - c_{LLU}} = q^i \qquad (12)$$

The fixed cost of entry via LLU at any given exchange i is dependent on the number of lines represented by the target share of lines, in this case 5%. In the largest exchanges, a 5% share of lines would require the entrant to invest in seven MSANs at a cost, according to the Opal/CPW data of £160,000. In any exchange with fewer than 10,000 lines (of which there are more than 4,600) only one MSAN is required with a capital cost of £40,000.

An Excel spreadsheet has been created including the costs outlined above to calculate the relative cost of LLU and BSA at each exchange. Based on this analysis, 1,789 exchanges were economically viable to unbundle before Ofcom imposed the price cut, if there were no additional cost of discrimination. These 1,789 exchanges accounted for 23.3 million premises (84%) of all properties. Thus the marginal exchange is the 1,789[th] largest exchange (Boston Spa).

After the price cut, the marginal exchange moved such that 2,636 exchanges, covering some 93% of premises, could be economically unbundled (Churnetside, West Midlands).

The price cut imposed by Ofcom had a substantial effect, therefore, but because of the asymmetric distribution of premises per exchange the additional 847 exchanges that became economically viable covered only 9% of households.

	4% Share		5% Share		6% Share	
	No. Exchanges	Percentage of Premises	No. Exchanges	Percentage of Premises	No. Exchanges	Percentage of Premises
Before Price Cut	1,588	81%	1,789	84%	1,943	87%
After Price Cut	2,379	91%	2,636	93%	2,866	94%

Table 12: Results of Breakeven Analysis (pre and post discount)

5.3.4 The Cost of Discrimination and the Effect of the Undertakings on the Marginal Exchange

Estimating the cost of discrimination, and the resultant marginal exchange, is substantially more difficult because such a cost is not directly observable and must be imputed from other evidence. The only evidence available is the number and characteristics of exchanges that were unbundled before 2005, when BT and Ofcom signed the Undertakings.

Observing these data we see a number of interesting characteristics. First the total premises in the unbundled exchanges increased by around 4,000 and the smallest exchange unbundled in 2004 was 4.5 times larger than the smallest exchange unbundled in 2003. Examining the data in more detail we see that whilst the average number of residential premises increased, the average number of business premises decreased by 17% (Table 14).

Year	Number	Mean Total Premises	Std. Dev.	Min	Max
2003	132	19,452	10,958	862	64,501
2004	99	23,553	9,504	3,853	44,757

Table 13: Mean Total Premises, Unbundled Exchanges 2003 - 04

Year	Mean Residential Premises	Mean Business Premises
2003	17,887	1,556
2004	22,262	1,286

Table 14: Mean Residential and Business Premises, Unbundled Exchanges 2003 - 04

This smallest exchange unbundled in 2003 was Wood Street in the City of London and so offered access to many business premises. Indeed, most of the smaller exchanges unbundled in 2003 were located in city centre business districts. This smallest exchange is smaller than would have been rational to invest in even after the price cut imposed by Ofcom and suggests that the investor was either irrational or, more likely, prepared to invest in such a small exchange because it expected broadband access based on LLU to find a more profitable market amongst business customer.

In 2004, the smallest exchange entered had 3,853 premises, and was again located in the City of London, this time in Moorgate, EC2. The largest exchange had declined from 64,501 to 44,757 but this is simply a function of the distribution of exchanges: the largest exchange unbundled in 2004 was the 6th largest exchange overall and all but two of the larger exchanges had been unbundled in 2003.

The changing characteristics of the exchanges suggests that ISPs were in a process of entrepreneurial discovery about where the most profitable market for LLU based broadband could be found. The change in the nature of unbundled exchanges between 2003 and 2004 can also be seen in Figure 25, which shows scatter plots of the number of residential and business exchanges unbundled in the two years. In 2003 the correlation coefficient is low at 0.22, whilst in 2004 in increases substantially to 0.62, which is still below the level of all years of 0.84.
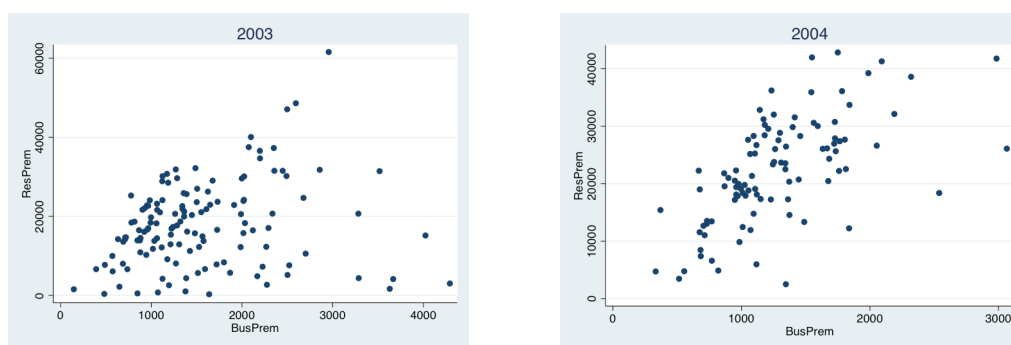
Figure 25: X-Y Scatter Plots of Residential and Business Premises

Figure 26 shows the distribution of the actual number of exchanges unbundled versus the expected number for each telephone exchange region of the UK in 2003 and 2004. The expected number is calculated as the proportion of exchanges unbundled nationally (4.1%) applied to each region. Hence we would expect that in London West (LW) where there are 53 exchanges, 2.2 would be unbundled. In fact between the two years, 25 LW exchanges were unbundled. Unsurprisingly, the areas where the actual unbundled exchange areas exceeded the expected numbers are all urban areas: London West, City of London, Westminster, South London, Central Midlands, West End and London North.

In 2005, no exchanges were unbundled. This may reflect uncertainty regarding the outcome of Ofcom's strategic review of telecommunications or learning by unbundlers that it is not possible for them to earn a profit from unbundled exchanges.

Figure 26: Actual vs. Expected Unbundled Exchanges: 2003 - 2004
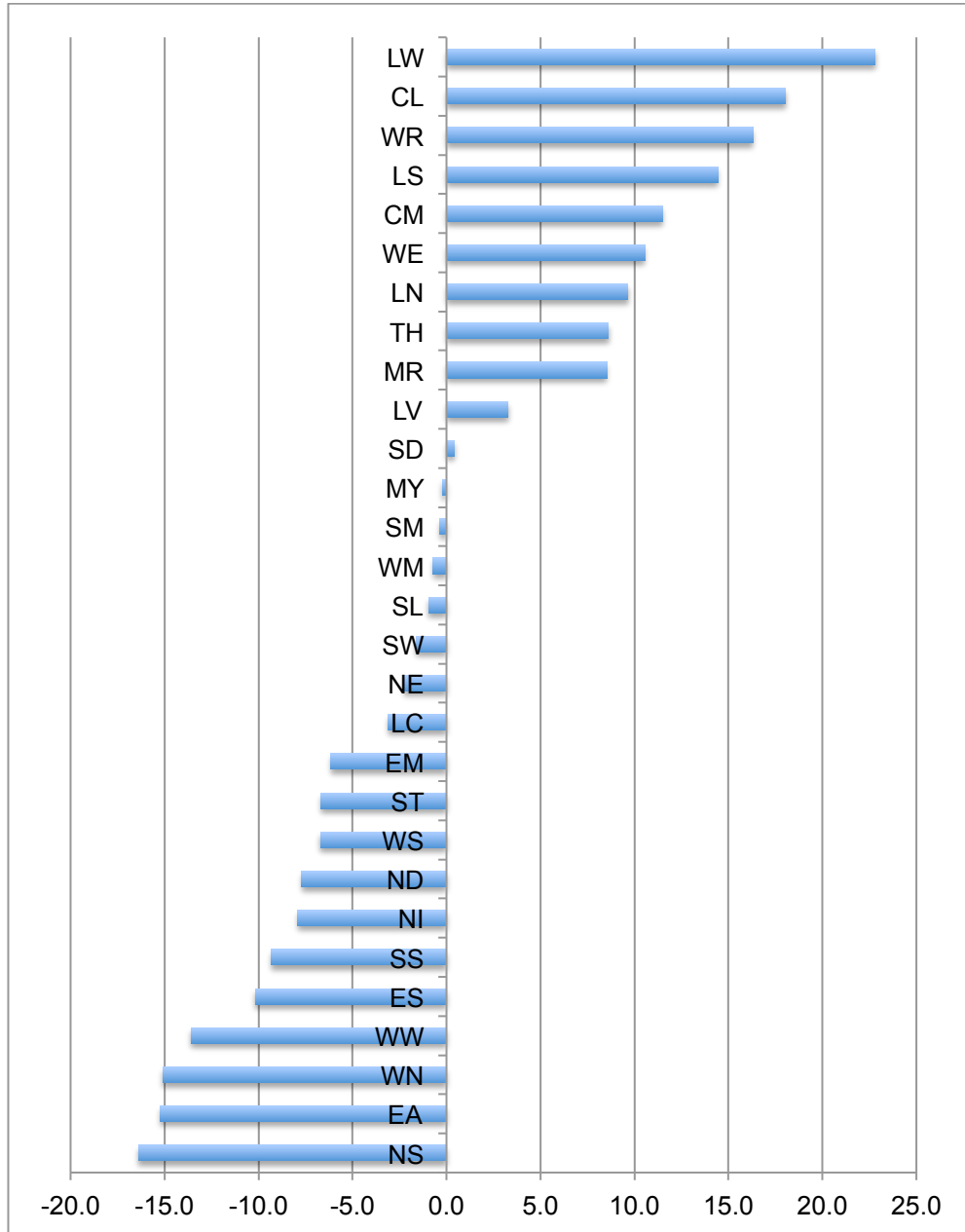
(See Annex D for a key to BT exchange region codes.)

As has been discussed at length in this thesis, a general assumption is that ISPs were concerned that BT could discriminate against them and raise their cost of market entry, but this cost cannot be observed directly. A further assumption for the breakeven model is that the equilibrium marginal exchange in the presence of discrimination had not been discovered by ISPs in 2004 but that, given the changing characteristics of unbundled exchanges between 2003 and 2004, it was likely to be a larger exchange than the smallest one unbundled in 2004. Some exchanges unbundled in both years were therefore likely to be the smaller than would have been rational for ISPs to unbundle had the cost of discrimination been directly observable. The next task, therefore, is to estimate where that marginal exchange might be found.

There is no economic way to make such an estimate. Therefore, two approaches are deployed based on the mean and the smallest exchanges. The first approach assumes that the marginal exchange is one standard deviation smaller than the mean number of total premises in 2004. Given a mean that year of 25,553 and a standard deviation of 9,504, the marginal exchange would have 14,049 premises.

The second approach assumes that the smallest 10% of exchanges unbundled that year were smaller than the marginal exchange. This would mean that the marginal exchange would have 10,823 residential and business premises.

The same approach has been adopted using the exchanges unbundled in 2003 to provide further sensitivity analysis.

Table 15 shows the implied cost of discrimination per exchange for each of 2003 and 2004 using equation (10), that is:

$$D_{LLU}^i = q(c_{BS} - c_{LLU}) - F_{LLU}^i$$

The table also shows the resultant location of the marginal exchange, using the two methods discussed above for each year. This calculation suggests that, using the standard deviation, in 2003 the cost of discrimination was £786 per exchange increasing to £1,323 in 2004. Setting the marginal exchange at the 10th percentile implies a cost of £495 and £782 respectively. Of course, the results would be different if some other location of the marginal exchange were chosen but, despite a degree of arbitrariness, these two locations can be regarded as reasonable.

Year	Relative Position	Total Premises	Assumed Share (5%)	Cost of Discrimination	Marginal Exchange
2003	10%	7,030	351	£495	4,272
	1SD from Mean	8,794	440	£786	4,485
2004	10%	10,823	541	£782	4,674
	1SD from Mean	14,049	702	£1,323	4,942

Table 15: Implied Cost of Discrimination

The analysis above has calculated the location of the marginal exchange at three points in time: before the implementation of the Undertakings, between the Undertakings and the price cut imposed by Ofcom, and after the price cut. This allows us to unbundle the effect of the Undertakings and the price cut and the proportion of premises that it would have been economic to serve by unbundlers. A summary of these results is shown in Table 16 below, using the lowest and highest estimation of the cost of discrimination.

	Before Undertakings		Before Price Cut	After Price Cut
	Lowest	Highest		
Marginal Exchange	4,272	4,941	3,793	2,946
Number of economic exchanges	1,309	640	1,789	2,636
Proportion of Premises in economic areas	75%	50%	84%	93%

Table 16: Location of Marginal Exchange over Time

The effect of the Undertakings was to increase the number of economic exchanges by between 479 and 1,148 by reducing the implied cost of discrimination by a maximum of £1,323. This allowed a further 34% and 9% of premises to be economically covered by ISPs using local loop unbundling.

The price cut moved the marginal exchange by a further 847 exchange, but, as these exchanges were all much smaller, added only a further 9% of premises.

These results are shown graphically below in Figure 27 using the low and high measures of discrimination.

Figure 27: Location of Marginal Exchange

Exchanges in increasing order of size
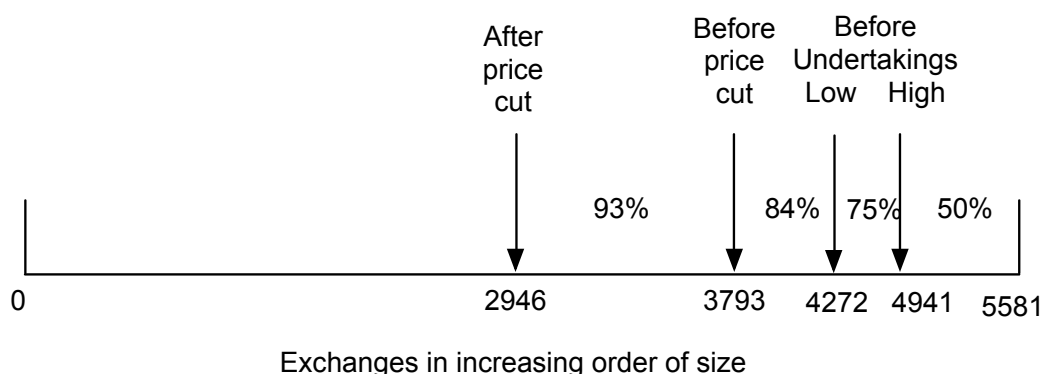
In conclusion, Ofcom's twin action of agreeing the Undertakings with BT and imposing a price cut for local loop unbundling increased the economically viable market by between 1,030 and 1,700 exchanges covering between 17% and 42% of households. Whether the Undertakings had a greater impact than the price cut depends on which measure of the marginal exchange before the Undertakings is used.

However, the implied cost of discrimination was not as high as may have been thought. ISPs could, therefore, have unbundled more exchanges than they did even without either the Undertakings or the price cut. .

At the time of writing this thesis, TalkTalk had unbundled 2,720 exchanges, which is 84 (3%) more exchanges than the breakeven analysis above would suggest.

The short-term effects of the Undertakings and price cut moved the marginal exchange towards smaller exchange areas. This has had an effect on competition and regulation of the Wholesale Broadband Access (WBA) market[74]. Under the EU common regulatory framework, NRAs are required to conduct market reviews every three years and the EC recommends a set of markets that are susceptible to *ex ante* regulation, one of which is the WBA market in which bitstream is the principal product over copper access lines.

In its 2007 review, Ofcom first introduced the concept of geographic markets based on homogeneous competitive conditions in exchange areas. In 2007 they identified three geographic markets (outside the Hull area), which they named markets 1, 2 and 3. They found BT to have SMP in markets 1 and 2, but no firm to have SMP in market 3. In the 2010 and 2013 Ofcom again found different geographic markets, one of which (market 3 in 2010 and market B in 2013) was not subject to SMP. What is relevant for this thesis is that the size of the competitive market has increased over time. This evolution is shown in Table 17.

Date of Ofcom Statement	Market Name	Definition	Percentage of premises in market
2007	3	BT plus three Principal Operators (POs).	69.2%
2010	3	BT plus three POs and BT plus 2 POs but BT's market share less than 50%.	71.3%
2014	B	BT plus two POs.	89.8%

Table 17: Evolution of Competitive WBA Market

According to Ofcom's most recent review of the WBA market, nearly 90% of premises are in exchange areas where there is sufficient competitive supply at the bitstream level that all *ex ante* regulation can be removed.

5.4   An Alternative Example: France

The UK was not the only country to introduce local loop unbundling to stimulate competitive entry in the broadband market. Table 18 shows the date of publication of a reference offer for LLU in the five largest EU Member States (EU5) along with the launch date of a retail DSL product.

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[74] In October 2014 the EC made a new Recommendation on Relevant Markets and changed the name of the WBA market to the Wholesale Central Access market. This thesis refers to the WBA market, as the last time Ofcom undertook a market review it was still called WBA.

	Full LLU*	**Shared Access***	**Retail DSL****
France	16 July 2001	16 July 2001	November 1999
Germany	11 April 2000	Not published	August 1999
Italy	5 January 2000	Not published	December 1999
Spain	21 January 2001	21 January 2001	1999
UK	31 December 2000	31 December 2000	July 2000

(* European Commission, 2001, Annex 2.1, Table 1
** OECD, 2001, Table 1)

Table 18: LLU Reference Offer Implementation Dates

This section of the thesis briefly compares the developments in France with those in the UK. France has been chosen for the demographic and economic similarities to the UK and the very different pattern of diffusion of LLU:CCA, illustrated in Figure 28. Sufficient data are not available to analysis the location of marginal exchange.

Figure 28: Diffusion of LLU:CCA in France and UK
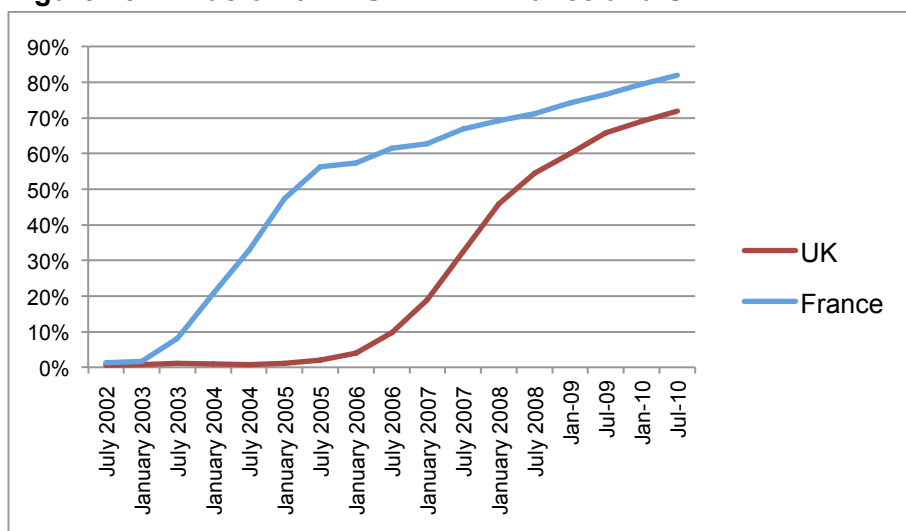
Figure 28 shows that, whereas LLU remained a tiny proportion of CCA in the UK until after the 2005 reforms, it diffused much earlier in France, starting in 2003, but then slowed down after 2005. Why might this be? This thesis has examined the effect of prices and a change in non-discrimination rules on diffusion in the UK, and now looks at whether these two factors have parallels in France, starting with prices.

As already shown in Table 9, LLU prices in France were substantially lower than they were in the UK in 2003. The regulated prices in the UK for fully and partially unbundled local loops were 1.5 and 2.4 times higher respectively than they were in France. By 2005 prices for fully unbundled loops were roughly comparable whereas shared access loop prices were lower in the UK than France. In the meantime, France had also reduced its LLU prices. It is immediately obvious from this chart that prices in France were significantly lower than the UK and that diffusion of LLU in the UK only began once prices had fallen, which they did at

the same time as prices in France. This could suggest that there was a pricing tipping point, somewhere between €19 and €10 per month at which competitive providers were prepared to enter the market using the LLU, although there is insufficient evidence available to measure whether this is the case empirically.

Figure 29 below reproduces Figure 19 adding in prices and diffusion for France. It is immediately obvious from this chart that prices in France were significantly lower than the UK and that diffusion of LLU in the UK only began once prices had fallen, which they did at the same time as prices in France. This could suggest that there was a pricing tipping point, somewhere between €19 and €10 per month at which competitive providers were prepared to enter the market using the LLU, although there is insufficient evidence available to measure whether this is the case empirically.

Figure 29: LLU Price and Diffusion, France and UK: 2003 - 2010
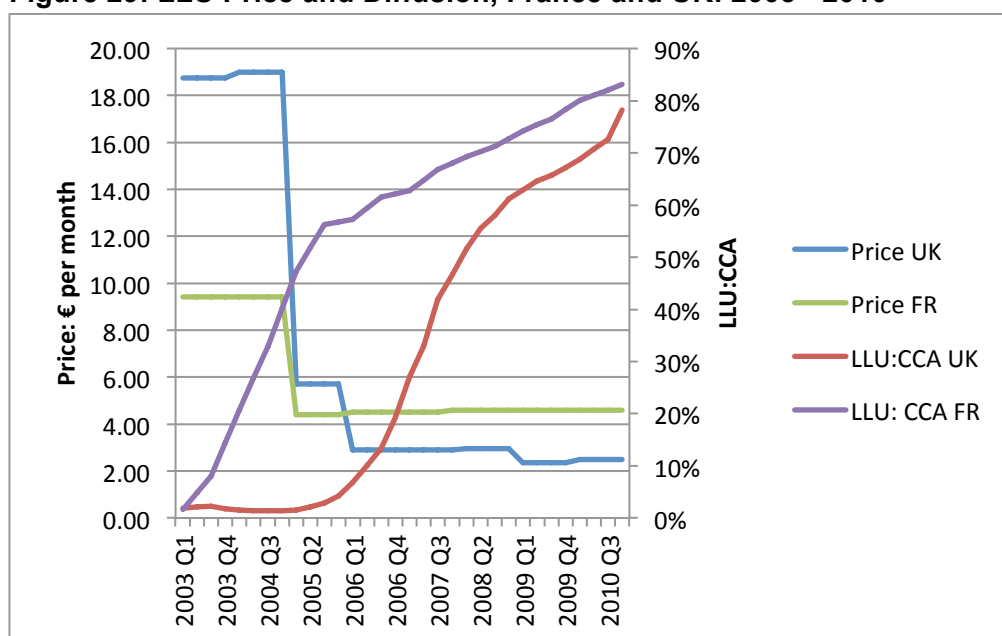
An alternative explanation is that the lower LLU price in France meant that there was a greater margin between the wholesale and retail prices and this would encourage more entry via LLU. Unfortunately, no historic price data are available to test such a hypothesis but in 2012 the median price per megabit of download speed in France was approximately twice the level of the UK. If the same were the case in period from 2003 – 2005, then LLU entry would be likely to be higher, especially given the lower price of LLU.

Equation (5) has been estimated using data for France. The results were very weak, showing a R^2 of 0.02 and so these are not reported.

The French regulator, now ARCEP[75] but at the time ART[76], did not consider it necessary to introduce either functional separation or EoI. In fact ART was

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[75] "Autorité de Régulation de Communications Électroniques et des Poste
[76] Agence de Régulation de Télécommunications

opposed to the idea, considering it not cost effective. If the LLU:CCA ratio is a measure of discrimination as proposed above, the higher ratio in France would suggest that non-price discrimination was not an issue. Or it could be that the available margin between the retail price of broadband and the LLU price was sufficient for entrants to earn a high enough return to cover the additional cost of discrimination.

It is not possible to draw hard and fast conclusions from this comparison between the UK and France. However, some general points can be made:

1)   The lower price of LLU in France in 2003 – 2005 is correlated with a much earlier increase in the LLU:CCA ratio.
2)   However, when France reduced its LLU prices in 2005 there was no change in the rate of LLU:CCA diffusion. In fact, a year or so later there was a sharp deceleration in the rate of change.
3)   The diffusion of LLU:CCA does not follow the same curve in France and the UK. The UK has a classic S shaped diffusion curve, whilst in France the proportion increases rapidly and then suddenly slows down.

Overall, it appears that two countries have followed different paths and the analysis of the diffusion of LLU:CCA in the UK does not make it possible to distinguish the separate effects of the price cut and the Undertakings. If one were to ask what would have happened in the UK if one or other measure had not been introduced, or if the prices in 2003 were similar to those in France, it would not be possible to answer from this brief analysis.

5.5   Conclusions from Chapter 5

This chapter has shown that Undertakings had the effect of moving the marginal exchange from the one that covered between the 50th and 75th percentile of customer premises to the one that covered the 84th percentile. The price reduction moved the marginal exchange to the 93rd percentile. These two measures were, therefore, successful in expanding the market that could be served by LLU. The perceived discriminatory behaviour of BT that reduced the size of the market that could be served by LLU was, therefore, successfully corrected. However, the analysis also shows that entrants were unnecessarily constrained by their expectation of BT's discriminatory behaviour and could have unbundled many more exchanges than they had before Ofcom's reforms.

There are two acknowledged issues with the model as presented. The first is that the only data available on the costs of unbundling an exchange are those included in Opal/CPW (2006). The breakeven model was designed to fit the data available and is, therefore, necessarily somewhat stylised. It could be improved if more detailed data were available. Even so, the results of the model come close to the number of exchanges unbundled by TalkTalk.

Secondly, the lack of data before 2005 means that assumptions have to be made about the location of the marginal exchange and therefore the amount by which rivals' costs were raised. A valid criticism would be that this allows the marginal exchange to be located wherever the author wishes it to be. The use of standard statistical measures (the standard deviation and the 10th percentile) are designed to minimise this effect, though their arbitrariness is recognised.

Since 2005 technology has evolved and fibre-based Next Generation Access (NGA) has moved up both the commercial and political agenda. BT has begun to roll-out fibre more deeply into its network to offer higher broadband access speeds to consumers. The next Chapter of this thesis will explore whether there is a connection between the regulatory reforms of 2005 and the geographic choice of where BT has decided to install fibre first.

6   Empirical Analysis 2: Next Generation Access

This section analyses the long-term effects of the Undertakings on BT's decision determining where to install NGA, principally via fibre to the cabinet (FTTC). The effect of the presence of the two unbundlers (Sky and TalkTalk) is compared with the effect of the presence of VirginMedia, the cable operator, along with other variables that may affect BT's choice. A probit model is used to determine the relative effects. The analysis shows that the presence of unbundlers has a stronger marginal effect on BT's choice than cable, but that even stronger still are direct policy measures such as the government's pressure to promote fibre in Northern Ireland.

6.1   Definition of Next Generation Access

Next Generation Access (NGA) is a general term, with no specific definition, that refers to higher bandwidth access to the Internet than current generation access. As a working definition, the highest speed available on copper from the local exchange is about 24 Mbps using ADSL2+. Access methods that provide higher speeds, in particular using fibre for at least part of the connection between the customer premises and the exchange, are considered to be NGA.

Fibre access networks can run between the exchange building and several points before the premises, as illustrated in Figure 8. The four principal places are:

- Fibre to the Node (FTTN**)**: Fibre is terminated in a street cabinet, possibly several kilometres away from the customer premises, with the final connections being copper.
- Fibre to the Cabinet (FTTC): This is very similar to FTTN, but the street cabinet or pole is closer to the user's premises, typically within 300m, meaning that the distance the signal has to travel over copper is shorter, thereby offering higher speeds to the user.
- Fibre to the Building/Premises (FTTB/P): Fibre reaches the boundary of the building, such as the basement in a multi-dwelling unit, with the final connection to the individual living space being made via alternative means, potentially an internal wired or wireless network.
- Fibre to the home (FTTH): Fibre reaches the boundary of the living space, such as a box on the outside wall of a home.

Collectively these different approaches are referred to as FTTX. The main approach taken by BT is FTTC.

The speeds available over the options vary from around 50Mbps to almost no upper bound for FTTH. However, for the purposes of this analysis, the exact form of FTTX or the bandwidth offered are not important, only the fact that BT decides to install FTTX in a particular exchange area.

An alternative form of NGA takes place on cable networks (in the UK, Virgin Media) and is known as DOCSIS3[77]. This technology allows for speeds of around 150 Mbps to be offered to end users of cable networks.

6.2   Policies to promote Next Generation Access

There is a general belief in policy-making circles that widespread availability of NGA is essential to economic growth. The UK government, for example, set out its broadband policy in 2010 stating:

> *"A world-class communications network will help the economy grow as we recover from the recession. As consumers we will have even greater choice and costs will be reduced. The delivery of public services will be more efficient and cost effective, as well as more inclusive. The way we access entertainment will alter, with greater options for consumers. Demand for better connectivity is growing as services and applications that take advantage of the greater bandwidth emerge."* (BIS/DCMS, 2010)

The UK government set aside some £1,000 million to support "superfast broadband" initiatives such as the roll-out of fibre in rural areas where the market would be unlikely to supply broadband by itself. It has set up a programme, Broadband Delivery UK (BDUK), within the Department of Culture, Media and Sport (DCMS) that has the following objectives:

- Provide basic broadband (2Mbps) for all by 2016.
- Provide superfast broadband coverage to 90% of the UK by 2016, 95% by 2017 and explore options to get near universal superfast broadband coverage across the UK by 2018.
- Create 22 "SuperConnected Cities" across the UK by 2015.
- Improve mobile coverage in remote areas by 2016.

BDUK has three programmes to achieve this:

Superfast Broadband Programme
To provide superfast broadband (speeds of 24Mbps or more) for at least 95% of UK premises and universal access to basic broadband (speeds of at least 2Mbps).

SuperConnected Cities Programme
To support UK cities to develop the digital infrastructure capability that the government hopes will ensure that UK cities are "internationally competitive and attractive for investors, business and visitors."

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[77] Data Over Cable Service Interface Specification.

Mobile Infrastructure Project
An investment of up to £150 million in mobile infrastructure to improve coverage for voice calls and text messages for the final 0.3-0.4% of UK premises that don't currently have it. (DCMS, 2014)[78]

Nevertheless, by far the largest investment in NGA is coming from the private sector. There are a number of networks being installed by smaller providers, as set out in Table 19, but the largest investor in NGA is BT, which is upgrading many of its exchanges to FTTX to deliver higher speed broadband. This section explores whether the policy changes of 2005 have had long-term effects on the development of the broadband market.

Type of deployment	Examples (not exhaustive)
Commercial NGA networks	Cityfibre: wholesale provider of fibre infrastructure including joint venture announced with Sky and TalkTalk to roll-out FTTP in York. Cityfibre targets what it calls "second tier cities" and claims to have the UK's largest FTTH network in Bournemouth, covering 21,000 homes. Hyperoptic: Fibre to the Building to blocks of flats in cities including London, Cardiff, Reading, Bristol, Manchester, Liverpool and Leeds. Gigaclear: FTTP to rural villages. It claims to have 25 live projects and 50 being installed. The villages tend to be clustered in Leicestershire and Oxfordshire.
Commercial Satellite Networks	Satellite broadband: commercial satellite service providing up to 20 Mbit/s broadband. The leading provider is Avonline. Satellite providers claim national coverage.
Commercial wireless networks	There are several local wireless networks. For example: • Call Flow (Hampshire) • Thinking Wisp (Norfolk) • WiSpire (Norfolk)
Community NGA networks	Cybermoor and fibre broadband in Alston Moor, Cumbria. B4RN: FTTP in the rural north west of England. Shetland Telecom: wireless broadband around Lerwick.

(Ofcom, 2014B, supplemented by own research)
Table 19: Non-BT Deployment of Fibre Access Networks

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[78] https://www.gov.uk/broadband-delivery-uk#overview

6.3 The Effect of Unbundling on BT's Choice of Fibre Exchanges

The analysis above showed how the Undertakings moved the marginal exchange for LLU and therefore increased the proportion of premises in the UK that could be economically served by LLU and in which ISPs could offer their own service package within the technical confines of current generation broadband. This section examines whether that has had a longer term effect on BT's decision as to where to install FTTX for NGA. BT faces competition from both LLU-based ISPs (Sky and TalkTalk) and from Virgin Media and there is no reason to expect BT to respond more against one type of competitor than another. This section therefore examines BT's choice of where it invests in FTTX against the following hypothesis:

Hypothesis 3: BT has responded to increased competition by investing in FTTX and has not distinguished between competition from LLU-based ISPs and Virgin Media.

As at December 31st 2012, BT had installed FTTX in 1,305 exchanges covering 16.3 million premises, approximately 59% of the population. The location of the exchanges where BT has installed FTTC are shown in Figure 30. The demographic characteristics of the FTTX exchanges compared with LLU and Cable exchanges are set out in Table 20 below.

Figure 30: Location of FTTC Exchanges
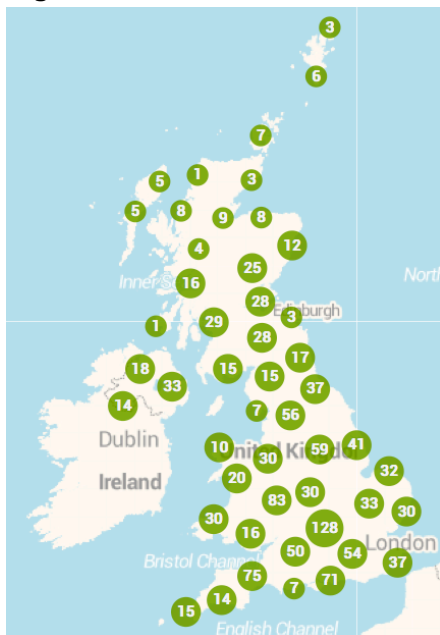
Technology	Mean Total Premises		Mean Population Density (persons per km²)		Median Income (£ per annum)		Sample (as at 31/12/12)
	Not Present	Present	Not Present	Present	Not Present	Present	
FTTC	2,634	12,482	5.4	27.6	30,177	29,996	1,305
LLU	1,227	11,424	2.2	25.2	30,318	29,813	2,030
Cable	2,343	12,963	3.7	31.7	29,761	31,288	1,363

Table 20: Characteristics of Exchanges by Technology

Given the larger number of exchanges where LLU has been installed, it is not surprising that these exchanges are, on average, both smaller and less densely populated than the FTTX exchanges.

The key interest here is the extent to which FTTX overlaps with other networks, i.e. has the presence of other technologies affected BT's decision to invest in FTTX? A simple way to answer this question is by counting the number of exchanges by FTTC where one or both of LLU and Cable are present. The results are shown in
Table 21.

Presence of other technologies on FTTX exchanges	Number (Percentage)
LLU	1,081 (83%)
Cable	746 (57%)

Table 21: Presence of Other Technologies in FTTX Exchanges

LLU is present in 83% of FTTX exchanges and Cable in 57%, which superficially suggests that BT is more concerned to use FTTX to compete against LLU than it is against Virgin Media.

The strength of the effect of LLU and cable on the likelihood that BT would choose to invest in FTTX is assessed econometrically using a binary choice model. This form of model assesses the effect that a range of variables may have on an individual's or firm's decision to choose between two options. In this case the model will assess the strength of the effect on BT's choice to invest or otherwise in FTTX at each exchange *i*. The two most popular forms of binary choice mode are the logistic function (a logit estimation) and the cumulative normal distribution (probit estimation). Both model forms have been developed and are reported here although there is very little difference between them. The generalised form of a binary choice model is

$$\Pr(y = 1|x) = G(x\beta) \qquad \qquad \textbf{(13)}$$

Where

$$G(x\beta) = \beta_1 + \beta_2 x_2 + \cdots + B_k x_k$$

What the model estimates, therefore, is the strength of the effect of each independent variable on the probability that y=1, that is that BT has invested in FTTX.

The factors that might affect where BT decides to invest in FTTX can be divided into three categories: demographic, competition and policy.

- Demographic variables refer to the number of premises and the population density of an exchange area, which in turn affect market size and cost of deployment.
- Competition refers to the presence of LLU-based competitors and the cable operator, Virgin Media, in an exchange area.
- Policy refers to specific public policy interventions to promote FTTX in certain regions, in particular Northern Ireland.

The decision to invest in FTTX has followed the expansion of LLU operators after the 2005 reforms. As has been shown above, these operators themselves tended to unbundle exchanges with a higher number of premises and in more densely populated areas first. Table 20 shows that the FTTX exchanges, like the LLU and Virgin Media exchange areas, have a significantly higher number of premises and population density than those without FTTX. Including both demographic and competition variables in the model may therefore lead to problems with the results due to multicollinearity. However, tests for multicollinearity in the data reveal that such a problem does not in fact exist (See

Annex B).

The model is cross-sectional at 31st December 2012. The equation, excluding the UK nation variables, is shown below:

$$FTTX = \beta_1 + \beta_2 LLU + \beta_3 VirginMedia + \beta_4 TotPrem \qquad \textbf{(14)}$$
$$+ \beta_5 PopDensity + \beta_6 Med\_Inc + \varepsilon$$

Where:

LLU is a dummy variable indicating whether one or both of Sky and/or TalkTalk is present in the exchange.
VirginMedia is a dummy variable indicating whether Virgin Media is available in at least 60% of the exchange area.
TotPrem is the total number of business and residential premises in the exchange area.

PopDensity is the population density measured in persons per km^2 of the local authority ward of the telephone exchange building.

Med_Inc is the median income of the post code of the exchange location.

The results of equation (14) have been calculated using both probit and logit models and the results are reported below for the average marginal effects (AME) for each variable. The average marginal effect (AME) calculates the response of individuals in the sample to a change in the value of an explanatory variable from any data point in the sample, rather than from a specific data point such as the mean. The marginal effects at the means (MEM) have also been calculated and there are no substantial differences in the results. The MEM results are reported in Annex C. P values are shown in brackets underneath the coefficients. The full Stata output of the logit and probit regressions before calculation of the AME are also shown in Annex C.

	1	2	3	4
LLU	0.29***	0.17***	0.17***	0.17***
	(0.00)	(0.00)	(0.00)	(0.00)
VirginMedia	0.11***	0.014	0.009	0.007
	(0.00)	(0.23)	(0.42)	(0.53)
TotPrem		0.000015***	0.000014***	0.000014***
		(0.00)	(0.00)	(0.00)
PopDensity			0.0005**	0.0005**
			(0.03)	(0.03)
Med_Inc				0.0000006
				(0.19)

*** significant at 1%, ** significant at 5%.
Table 22: Results of Logit Models, Average Marginal Effects

	1	2	3	4
LLU	0.29***	0.17***	0.17***	0.17***
	(0.00)	(0.00)	(0.00)	(0.00)
VirginMedia	0.12***	0.02*	0.013	0.013
	(0.00)	(0.10)	(0.28)	(0.30)
TotPrem		0.000015***	0.000014***	0.000014***
		(0.00)	(0.00)	(0.00)
PopDensity			0.0007***	0.0007***
			(0.00)	(0.005)
Med_Inc				0.0000001
				(0.76)

*** significant at 1%, ** significant at 5%, * significant at 10%.
Table 23: Results of Probit Models, Average Marginal Effects

The models show the increased (decreased) probability that BT will have invested in FTTX given the presence, or otherwise, of LLU operators and VirginMedia; the increased (decreased) probability of investment with one unit

increase in the total number of premises; and the population density of the exchange area. Thus, in model 1 for both the logit and probit calculations, there is a 29% increase in the average probability that BT will have invested in FTTX in the event that LLU is present. Whereas the increase in probability is only around 12% greater if Virgin Media is present.

Consistent throughout all the models is the finding that the presence of LLU operators has a much stronger effect on the likelihood that BT will invest in FTTX than the presence of VirginMedia. Where other factors are not included in the model, the likelihood is almost three times greater. In the other logit models the average marginal effect of Virgin Media is not significant and in probit model 4 the effect of LLU is about nine times greater than Virgin Media.

Demographic factors have only very weak effects on BT's investment decisions and the median income is not significant.

The results suggest that BT's decision to invest in NGA appears to be more influenced by the two LLU operators than by Virgin Media and so hypothesis 3 is rejected. This raises a question of whether BT regards Virgin Media as a strong competitor and so has entered the market to compete with LLU operators to avoid the strong competitor or, conversely, it competes with LLU operators because they are regarded as strong competitors that must be challenged. This question is addressed below.

Data for BT's market share at each exchange area are not available. However, Figure 31 plots the national retail market shares of BT, cable and the LLU operators over the period since the implementation of the Undertakings. It can clearly be seen from this chart that cable's market share has declined substantially over the period. In part this is because the cable network has not expanded beyond the approx. 55% of households it passed at the time the Undertakings were signed, whereas BT and LLU operators have extended their broadband network reach.

The chart also shows that LLU operators have, from a standing start in 2005, acquired a combined market share of over 40%, some nine percentage points greater than BT's. The market share of the cable operator continues to decline, albeit slowly.

The implication of this is that LLU operators present a much greater competitive threat to BT than Virgin Media. BT's investment in FTTC may therefore be a response to this threat by giving BT a superior product with which to compete against the LLU operators.

Figure 31: Retail Broadband Market Shares 2005 - 2012
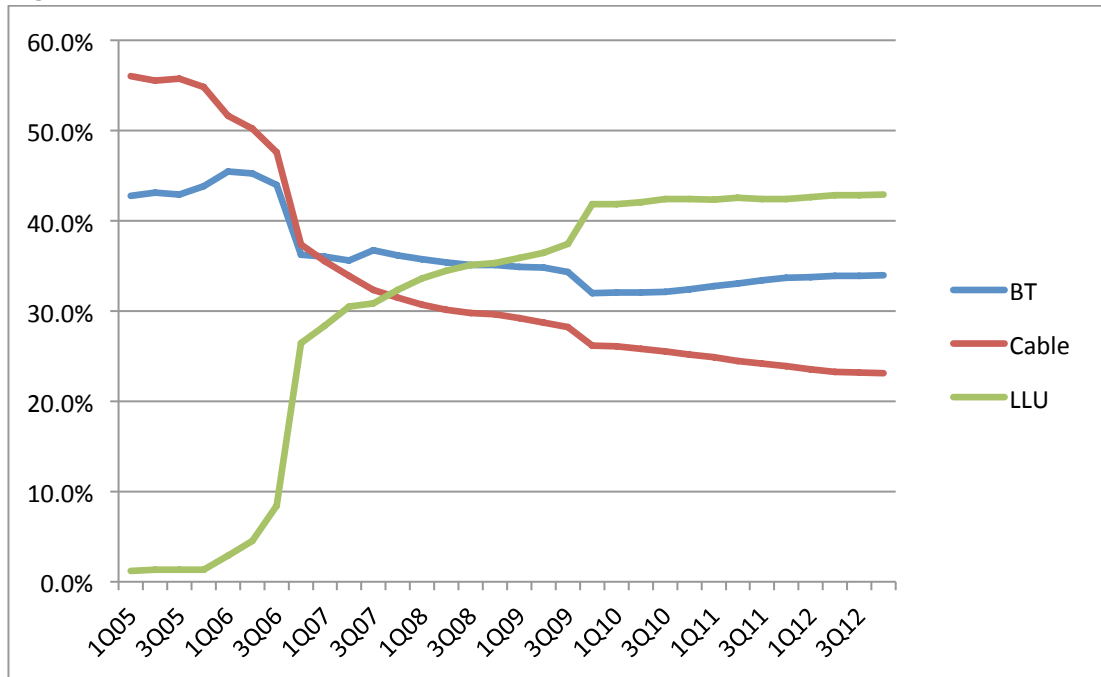
However, BT is under an obligation to provide wholesale access to its fibre service to rivals such as Sky and TalkTalk who can then offer equivalent services to those that BT Retail can offer. It might be thought that BT cannot therefore gain a competitive advantage over its rivals through its fibre investment, which raises the question: why would BT invest in fibre if it can gain no advantage?

To answer this it is necessary to review how competition in the electronic communications markets has evolved over recent years and, in particular, how consumers' purchasing behaviour has changed from buying single products to bundles. A "bundle" consists of two or more electronic communications services and consist of three main types:

- Dual play: Fixed voice and Internet (until 2007 Internet was accessed by either broadband or dial-up, but the latter has since ended completely).
- Triple play: Fixed voice, Internet and TV.
- Quad play: Fixed voice, mobile voice, Internet and TV.

Ofcom has tracked the purchasing behaviour of consumers with regard to bundles since 2005 through an annual consumer survey. Their data show how the proportion of consumers buying a bundle including TV has increased substantially over the period. In 2005, some 84% of consumers buying dual or triple play bundles (quad play bundles were not available at the time) bought dual play bundles and either bought TV outside the bundle or relied on "free to air" TV. At the time, 29% of households bought a bundle. By 2012, 57% of households bought a bundle and, of those, 41% bought bundles including PayTV. By 2014, this last figure had increased to 45% (Ofcom 2014). Ofcom's data is obtained from surveys, which may account for some of the variation between years;

however, the trend is clear. It is interesting to see that the rapid increase in the proportion buying triple play bundles coincides with the period when Sky and TalkTalk were rolling out LLU and thus increasingly able to control the service they provided.

The largest provider of PayTV in the UK is Sky, which provides TV over satellite. At the end of 2012 its share of the PayTV market was 68%, at which it had remained consistently since 2010[79]. Over the same time, Sky's share of the broadband market had increased from 13% to 19% to become the second largest provider after BT[80].

Figure 32: Evolution of Consumer Bundle Buying Behaviour
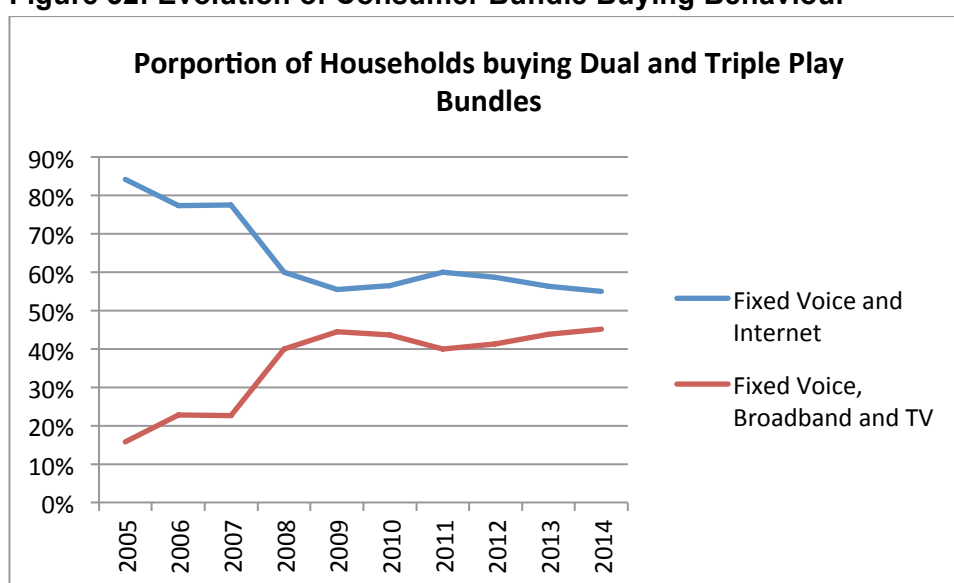
Without an FTTX offering, BT would not be able to provide TV to the same quality as Sky, as the maximum speeds available on copper-based broadband do not allow for a viewing experience equivalent to either Sky's satellite or Virgin Media's cable offering. BT therefore needed to invest in an infrastructure that could allow it to compete with Sky. As BT itself said:

> *"Triple-play bundles of TV, broadband and fixed-voice continue to grow in importance for customers. We have developed our TV and content offers – 2013/14 was a watershed year for us. We launched the award-winning BT Sport channels and acquired UEFA Champions League and UEFA Europa League football rights for three years from summer 2015. We also added 38 channels to our TV service… The number of homes taking two or more services in a bundle from a single provider continues to grow. Fibre broadband and BT Sport help us to compete better in this market."*

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[79] If the market is extended to include free-to-air digital TV (Freeview and Freesat) then Sky's market share falls to 39%.

[80] Source: Ovum Knowledge Centre

(BT, 2014)[81]

BT is refusing to sell its new BT Sport channel to Sky on a wholesale basis, as this would mean sharing subscription revenues and allowing Sky to price and package the channel in ways that could undermine the appeal of BT's own sports-centric TV-and-broadband packages. BT will instead sell BT Sport to satellite customers itself and bill them directly. It acquired two Electronic Programme Guide (EPG) slots on the Sky platform in November, a move that could not be resisted by Sky, given that open access to its EPG is enforced as part of the operator's broadcast license[82].

In November 2014, the Financial Times listed the various acquisitions of content providers by telecoms operators and explained:

> *"The backdrop for these moves is a shift towards 'quadplay', bundled offerings which include landline and mobile contracts as well as broadband and TV. If one company can offer all the aspects of communications and TV, it can produce a domino effect."* (Thomas et al., 2014).

The article also showed how the activities of leading telecoms operators overlapped in the four parts of the quad play offer, reproduced below. Since the article was published BT has purchased the mobile network operator EE, a move that would place it in the same areas as AT&T, Orange and Telefonica.

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[81] In January 2015 Ofcom launched a Competition Act inquiry into the sale of audio-visual rights to English Premier League matches following a complaint by Virgin Media. http://stakeholders.ofcom.org.uk/enforcement/competition-bulletins/open-cases/all-open-cases/cw_01138/?utm_source=updates&utm_medium=email&utm_campaign=cw_01138.

[82] Source: Ovum Knowledge Centre.

Figure 33: Telecom Operator Competitive Positioning

(Thomas et al., 2014)

Figure 34 illustrates the importance of TV in broadband offering. It shows selections from the websites of each of the four main broadband operators and how multi-play packages, including TV, are central to their product offerings.

Figure 34: Selection of Multi-Play Web Pages

So, whilst BT has to provide wholesale access to its fibre access network to both Sky and TalkTalk, BT is able to use that platform to compete aggressively with Sky in the PayTV and bundle market which, in turn, allows BT to maintain its leading position in the broadband access market.

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6.4   Direct Public Policy Intervention

The number of FTTX-enabled exchanges is not constant across the UK. Figure 35 shows the actual number of FTTX exchanges per region compared to the number of exchanges that would be fibred if all regions had fibred exchanges at the national average. The region with by far the highest number of enabled exchanges in comparison to the expected amount if all regions had the national average is Northern Ireland (NI), where 180 of the 191 exchanges (94%) were FTTX enabled at the end of 2012. The expected number would have been just 45. The other areas with an above average number of enabled exchanges were mainly in London (LS, LN and LW) and Manchester (MR). At the other end of the scale, the regions with the fewest FTTX-enabled exchanges were in Scotland (ES, NS, WS) and Wales (SW, WN).

The data presented in Figure 35 are confirmed in logit and probit models, including dummy variables for Northern Ireland, Scotland and Wales. The average marginal effects of these models are shown in Table 24.

Figure 35: FTTX Exchanges: Actual vs. Average
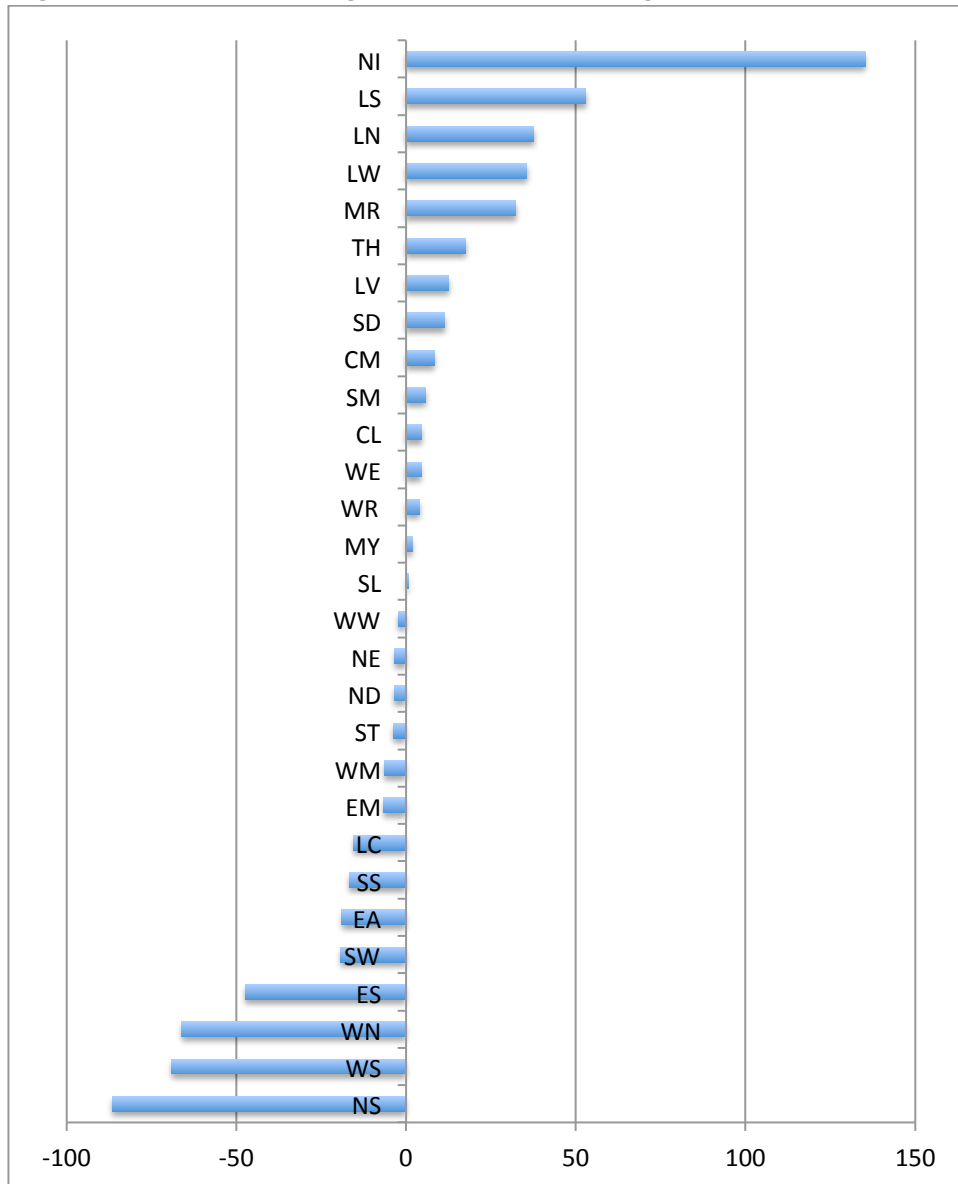
(See Annex D for a key to BT exchange area codes.)

Variable	Logit	Probit
LLU	0.18***	0.18***
	(0.00)	(0.00
VirginMedia	0.01	0.01
	(0.53)	(0.32)
TotPrem	0.00001***	0.00001***
	(0.00)	(0.00)
PopDensity	0.0002	0.0003
	(0.30)	(0.08)
Med_Inc	0.000002***	0.000001***
	(0.00)	(0.00)
NI	0.50***	0.49***
	(0.00)	(0.00)
SC	-0.14***	-0.14***
	(0.00)	(0.00)
WA	-0.07***	-0.07***
	(0.00)	(0.00)

*** significant at 1%

Table 24: Logit and Probit AME, including UK Nations Dummy Variables

The results differ from Table 22 and Table 23 for the continuous variables as *Med_Inc* becomes significant at the 1% level. However, as with the models without the UK nation dummies, these models show a stronger effect of LLU than Virgin Media (the coefficient on *VirginMedia* is not significant). The results also show a strong and significant positive effect for Northern Ireland (NI) and weaker, but significant effects for Scotland (SC) and Wales (WA). The results indicate that given like for like exchanges, there would be a 48% increase in the likelihood of FTTX in Northern Ireland, There would be 14% and 7% decrease in the likelihood of FTTX in Scotland and Wales respectively.

The increased probability of investment in fibre in NI is a result of direct public policy intervention by the Department of Enterprise, Trade and Investment (DETI) of the Northern Irish government.

In 2009 the UK government launched a process to upgrade the quality of broadband services in NI on the basis that the market, left to itself, would not do so. It intended to make available £18m, which would be awarded to the winning tenderer. The terms under which the support would be made available meant that this support counted as State Aid within the meaning of TFEU and therefore had to be assessed by the European Commission to ensure that it complied with the rules as they applied to broadband projects. The Commission informed the UK government in a letter dated 5/11/2009 that the proposed scheme was compatible with the treaty conditions and therefore the UK government could fund broadband development in NI.

The project involved BT investing in Fibre to the Cabinet to 1,265 street cabinets across NI, and BT later added a further 768 cabinets without further State Aid. NI

now has the highest density of exchanges with FTTC and above average connections to NGA.

NI is not the only area of the UK to receive support for broadband development. The government has been running a programme known as Broadband UK (BDUK) to support local projects in less populated rural areas. Figure 36 shows the extent of BDUK projects. A typical example is Better Broadband For Norfolk (BBFN)[83]. The county council and UK government have each allocated £15 million to support broadband in rural areas of the county using FTTX to ensure access speeds above 24Mbps. Without this support, Norfolk County Council estimated that 34,000 premises across the county would not be able to receive basic broadband by the end of 2015. The BBFN project is designed to ensure that 80% of premises will receive NGA by that time.

The data available does not allow support from BBFN and other BDUK schemes to be included in the model, and many schemes came into being after the end 2012. However, the NI data does show that BT's choice of where to invest in FTTX was not only driven by commercial criteria but in some areas the decision was also driven by direct policy intervention.

Figure 36: BDUK Local Broadband Projects

(DCMS, 2014[84])

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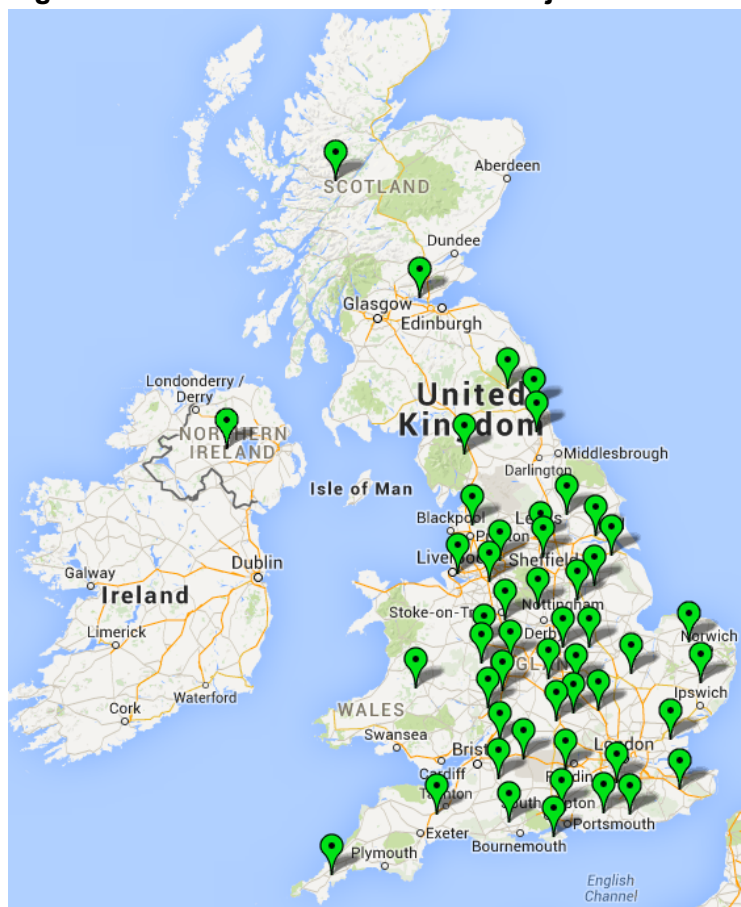
[83] http://www.betterbroadbandnorfolk.co.uk/default.aspx
[84] https://www.gov.uk/broadband-delivery-uk Downloaded 29/10/2014

6.5 Conclusions from Chapter 6

The analysis in this section suggests that up to December 2010 BT invested in FTTX primarily in response to the competitive threat from LLU operators rather than from Virgin Media. Hypothesis 3, which expected BT to be indifferent between the sources of competition, is therefore rejected. Direct public intervention, as happened in Northern Ireland, also had a strong effect on the introduction of FTTX.

7   Conclusions and Further Research

The UK broadband market started in 2000 with the cable operators and BT offering commercial broadband products to consumers. At the same time, BT offered two wholesale access products on its network that its competitors could use to offer retail broadband services: bitstream access and local loop unbundling. Bitstream allows the retailer little opportunity to differentiate its products from BT's whereas LLU does provide such an opportunity and can therefore be considered a superior product.

However, by mid-2005 there were very few broadband connections provided by LLU: just 85,000 of eight million total subscriptions, or less than 2% of all customer connections, by competitors using BT's access network. In 2004 the new sector regulator, Ofcom, launched its strategic review of telecommunications and appears to have been strongly influenced by BT's competitors to believe that non-price discrimination, or the fear of non-price discrimination, was a significant block for firms investing in market entry via LLU. It concluded from the review that the "no undue discrimination" obligation placed on BT was not sufficient to prevent at least the perception of discriminatory behaviour.

Ofcom and BT agreed a set of Undertakings, in lieu of a referral to the Competition Commission under the Enterprise Act, under which BT agreed to a set of behavioural and organisational changes with the aim of deterring discrimination. The behavioural commitment was a new, specifically *ex ante,* form of non-discrimination called Equivalence of Input (EoI). Under EoI, BT had to provide the same product to wholesale customers as it used itself, under the same terms, at the same price, on the same time scales, using the same systems and processes and providing the same commercial information. It was not sufficient for the outcomes to be same, the inputs had also to be the same.

The organisational change was that BT would establish a functionally separate Access Services Division (later branded Openreach) that would operate at arm's length from the rest of BT and would provide key access products to BT and external communications providers under EoI terms.

At the same time, Ofcom cut the regulated price of LLU by 85% and established a independent industry body, the Office of the Telecommunications Adjudicator (OTA), to establish a "fit for purpose" process under which communications providers purchased LLU.

This thesis has examined whether these regulatory changes had the desired effect in the short run: a reduction in the perceived level of discrimination; and whether they could also be credited with longer-term effects on the UK broadband market, in particular BT's location decisions on where to invest in Next Generation Access.

Two measures of non-price discrimination have been proposed: the ratio of LLU to all forms of competitive copper access (CCA) and the location of the marginal exchange.

The thesis finds that there is an intuitive causal relationship between the introduction of the regulatory changes and the LLU:CCA ratio, which was slightly declining before the changes but immediately starting growing following the changes. However, the data do not allow a formal testing of the relationship. It is also not possible to distinguish between the effect of the Undertakings and of the price cut.

The alternative analysis, the location of the marginal exchange, yields better results. The marginal exchange is located where the communications provider is indifferent between entry via LLU and entry via bitstream and its location is calculated using a breakeven analysis. The results indicate that before the Undertakings the marginal exchange was between numbers 4,272 and 4,942 of 5,581 and these exchanges covered 50% - 75% of the population. The Undertakings then moved the marginal exchange to number 3,793 and covered a further 9 - 34 percentage points of the population. Finally, the price cut moved the marginal exchange to number 2,946 and a further nine percentage points of the population.

From this analysis the thesis concludes that:

1)   Communications providers could have invested beyond the 321 exchanges they entered before the Undertakings were introduced.
2)   However, the Undertakings did have a positive effect on relocating the marginal exchange that was complemented by the price cut.

The second empirical analysis examines the way in which BT's choice of exchanges to upgrade to fibre was related to the presence of LLU operators (principally Sky and TalkTalk) versus the presence of Virgin Media, the cable operator. All competitors were assumed to be equal threats to BT and therefore BT's choice of where to invest in fibre would not be affected by which competitor was present.

Using a discrete choice model, however, the thesis establishes that BT was substantially more likely to invest in fibre in local exchange areas where LLU operators were present than where Virgin Media was present. The presence of Virgin Media was only significant when demographic factors were excluded from the model, and then LLU operators were found to have an effect three times stronger than that of Virgin Media.

This may be considered a perverse result given that BT is required to allow access to its fibre network to other operators such as Sky and TalkTalk and so may not be able to gain a competitive advantage. However, the broadband market is highly dynamic and the locus of competition has shifted from

broadband access speed to content. For BT to remain competitive it needed to be able to offer a TV package and for this it needed a fibre access network.

The thesis has also examined the effect of public policy on BT's location choice, especially in Northern Ireland, which has been the recipient of substantial state aid to support the roll out of NGA. Extending the discrete choice model to include dummy variables for the UK nations, except England, the analysis finds that an exchange in Northern Ireland is 50% more likely to fibred than an equivalent English exchange. Exchanges in Scotland and Wales are 14% and 7%, respectively, less likely to be fibred, as of the end of 2012.

Overall this thesis concludes that Ofcom's actions in 2005 were successful in removing the perceived level of non-price discrimination, and this can be seen in how the marginal exchange shifted in response to Ofcom's actions. However, it also finds discrimination was less of a threat than was perceived at the time and that, even without Ofcom's actions, 50% of UK customer premises could have been profitably served by LLU. BT's profit margins on its wholesale products suggest that it had only a weak incentive to discriminate.

In the longer term, the market dynamics resulting from increased competition led to BT responding to the threat from LLU operators by first investing in fibre access networks where Sky and TalkTalk were present.

Much of the debate about the Undertakings has concentrated on functional separation and has confused functional with structural separation. Opponents have been concerned that the separation of BT would reduce its investment incentives, in part because upstream and downstream operations could not co-ordinate requirements. BT's investment strategy following the Undertakings suggests that these concerns were misplaced.

This thesis has concentrated on wholesale markets and has not investigated the effects of the regulatory changes on consumers, which would be a fruitful area for further independent research. The thesis is also only concerned with the UK and does not compare outcomes in the UK with other countries and this would also be a fruitful area of further independent research.

Annex A: Results of Diffusion Equation

85% Saturation

```
      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  1,    29) =    20.97
       Model |  .096577641        1  .096577641        Prob > F      =   0.0001
    Residual |  .133542646       29  .004604919        R-squared     =   0.4197
-------------+------------------------------           Adj R-squared =   0.3997
       Total |  .230120287       30  .007670676        Root MSE      =   .06786
```

```
-------------------------------------------------------------------------------
   switch_85 |      Coef.   Std. Err.       t    P>|t|     [95% Conf. Interval]
-------------+-----------------------------------------------------------------
      LLUCCA |   .2008934     .043867      4.58   0.000     .1111752    .2906116
       _cons |   .0128403    .0178502      0.72   0.478    -.0236674     .049348
```

90% Saturation

```
      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  1,    29) =    20.86
       Model |  .055034948        1  .055034948        Prob > F      =   0.0001
    Residual |  .076510129       29   .00263828        R-squared     =   0.4184
-------------+------------------------------           Adj R-squared =   0.3983
       Total |  .131545078       30  .004384836        Root MSE      =   .05136
```

```
-------------------------------------------------------------------------------
   Switch 90 |      Coef.   Std. Err.       t    P>|t|     [95% Conf. Interval]
-------------+-----------------------------------------------------------------
         P   |   .1516515    .0332038      4.57   0.000     .0837421    .2195609
       _cons |   .0151529    .0135111      1.12   0.271    -.0124805    .0427863
-------------------------------------------------------------------------------
```

95% Saturation

```
      Source |       SS       df       MS              Number of obs =      31
-------------+------------------------------           F(  1,    29) =    19.32
       Model |  .035507305        1  .035507305        Prob > F      =   0.0001
    Residual |  .053304897       29    .0018381        R-squared     =   0.3998
-------------+------------------------------           Adj R-squared =   0.3791
       Total |  .088812202       30  .002960407        Root MSE      =   .04287
```

```
-------------------------------------------------------------------------------
   switch_95 |      Coef.   Std. Err.       t    P>|t|     [95% Conf. Interval]
-------------+-----------------------------------------------------------------
      LLUCCA |   .1218109    .0277148      4.40   0.000     .0651278    .1784941
       _cons |   .0158807    .0112776      1.41   0.170    -.0071845    .0389459
-------------------------------------------------------------------------------
```

Annex B: Multicollinearity Tests

Table 25 below shows the correlation coefficients for the demographic and competition variables and Table 26 shows the Variance Inflation Factor (VIF) and Tolerance (which is the reciprocal of the VIF) for the same variables. The VIF quantifies the severity of multicollinearity. It provides an index that measures how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of collinearity. Whilst there is no hard and fast rule as to the level of correlation of VIF that is acceptable, an acceptable rule of thumb is that a correlation less then 0.8 or a VIF less than 10 would suggest that there is unlikely to be a problem with multicollinearity (Williams, 2014). The values shown below suggest that there are no problems of multicollinearity.

	LLU	VirginMedia	TotPrem	PopDensity	Med_Inc
LLU	1.0000				
VirginMedia	0.5699	1.0000			
TotPrem	0.6808	0.6330	1.0000		
PopDensity	0.5066	0.5519	0.6514	1.0000	
Med_Inc	-0.0252	0.0675	-0.0390	0.0279	1.0000

Table 25: Correlation Table

Variable	VIF	1/VIF
TotPrem	2.67	0.375
LLU	1.99	0.502
VirginMedia	1.89	0.530
PopDensity	1.85	0.540
Med_Inc	1.02	0.981
Mean VIF	1.88	

Table 26: Variance Inflation Factors

Annex C: MEM Results

	1	2	3	4
LLU	0.31***	0.20***	0.20***	0.20***
	(0.00)	(0.00)	(0.00)	(0.00)
VirginMedia	0.12***	0.02	0.01	0.009
	(0.00)	(0.23)	(0.42)	(0.53)
TotPrem		0.00002***	0.00002***	0.00002***
		(0.00)	(0.00)	(0.00)
PopDensity			0.006**	0.0006**
			(0.026)	(0.03)
Med_Inc				0.0000007
				(0.19)

*** significant at 1%, ** significant at 5%.

Table 27: Results of Logit Models, Average Marginal Effects

	1	2	3	4
LLU	0.34***	0.22***	0.21***	0.21***
	(0.00)	(0.00)	(0.00)	(0.00)
VirginMedia	0.14***	0.02*	0.02	0.02
	(0.00)	(0.10)	(0.28)	(0.30)
TotPrem		0.00002***	0.00002***	0.00002***
		(0.00)	(0.00)	(0.00)
PopDensity			0.0009***	0.0009***
			(0.005)	(0.005)
Med_Inc				0.0000002
				(0.76)

*** significant at 1%, ** significant at 5%, * significant at 10%.

Table 28: Results of Probit Models, Average Marginal Effects

Results of Logit and Probit Regressions


```
. logit FTTC LLU VirginMedia

Iteration 0:   log likelihood = -3035.0264
Iteration 1:   log likelihood = -2276.3355
Iteration 2:   log likelihood = -2209.9593
Iteration 3:   log likelihood = -2208.7615
Iteration 4:   log likelihood = -2208.7612

Logistic regression                             Number of obs   =       5580
                                                LR chi2(2)      =    1652.53
                                                Prob > chi2     =     0.0000
Log likelihood = -2208.7612                     Pseudo R2       =     0.2722

------------------------------------------------------------------------------
        FTTC |     Coef.   Std. Err.      z    P>|z|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
         LLU |  2.343633   .0900892    26.01   0.000    2.167061    2.520205
 VirginMedia |   .885861   .0843243    10.51   0.000    .7205885    1.051134
       _cons |   -2.7308   .0686287   -39.79   0.000    -2.86531    -2.59629
------------------------------------------------------------------------------
```

```
. logit FTTC LLU VirginMedia  TotPrem

Iteration 0:   log likelihood = -3035.0264
Iteration 1:   log likelihood = -2089.4754
Iteration 2:   log likelihood = -2036.6209
Iteration 3:   log likelihood = -2036.0249
Iteration 4:   log likelihood = -2036.0246
Iteration 5:   log likelihood = -2036.0246

Logistic regression                          Number of obs   =       5580
                                             LR chi2(3)      =    1998.00
                                             Prob > chi2     =     0.0000
Log likelihood = -2036.0246                  Pseudo R2       =     0.3292

------------------------------------------------------------------------------
        FTTC |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         LLU |   1.496439   .1052949    14.21   0.000     1.290065    1.702813
  VirginMedia |   .1209414   .1006365     1.20   0.229    -.0763025    .3181852
     TotPrem |   .0001335   8.22e-06    16.24   0.000     .0001173    .0001496
       _cons |  -2.869872   .0699475   -41.03   0.000    -3.006966   -2.732777
------------------------------------------------------------------------------


. logit FTTC LLU VirginMedia  TotPrem  PopDensity

Iteration 0:   log likelihood = -3018.3484
Iteration 1:   log likelihood = -2065.6454
Iteration 2:   log likelihood = -2010.8232
Iteration 3:   log likelihood = -2010.1082
Iteration 4:   log likelihood = -2010.1079
Iteration 5:   log likelihood = -2010.1079

Logistic regression                          Number of obs   =       5562
                                             LR chi2(4)      =    2016.48
                                             Prob > chi2     =     0.0000
Log likelihood = -2010.1079                  Pseudo R2       =     0.3340

------------------------------------------------------------------------------
        FTTC |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         LLU |   1.520583   .1059651    14.35   0.000     1.312895     1.72827
  VirginMedia |   .0828958   .1035408     0.80   0.423    -.1200404    .2858321
     TotPrem |   .0001249   8.85e-06    14.12   0.000     .0001076    .0001423
   PopDensity |   .0048295   .0021689     2.23   0.026     .0005785    .0090804
       _cons |   -2.89757   .0709154   -40.86   0.000    -3.036562   -2.758579
------------------------------------------------------------------------------


. logit FTTC LLU VirginMedia  TotPrem  PopDensity  Median_Income

Iteration 0:   log likelihood = -3018.3484
Iteration 1:   log likelihood = -2065.0004
Iteration 2:   log likelihood = -2009.9517
Iteration 3:   log likelihood = -2009.2312
Iteration 4:   log likelihood = -2009.2308
Iteration 5:   log likelihood = -2009.2308

Logistic regression                          Number of obs   =       5562
                                             LR chi2(5)      =    2018.24
                                             Prob > chi2     =     0.0000
Log likelihood = -2009.2308                  Pseudo R2       =     0.3343

------------------------------------------------------------------------------
        FTTC |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          LLU |   1.526319    .106068    14.39   0.000      1.31843    1.734209
  VirginMedia |   .0653616    .104373     0.63   0.531    -.1392056    .2699288
      TotPrem |   .0001261   8.91e-06    14.16   0.000     .0001087    .0001436
   PopDensity |   .0046729   .0021749     2.15   0.032     .0004102    .0089355
Median_Income |   5.50e-06   4.15e-06     1.33   0.185    -2.63e-06    .0000136
        _cons |  -3.066149   .1464747   -20.93   0.000    -3.353234   -2.779064
------------------------------------------------------------------------------
```

```
. probit FTTC LLU VirginMedia

Iteration 0:   log likelihood = -3035.0264
Iteration 1:   log likelihood = -2221.4389
Iteration 2:   log likelihood = -2209.0497
Iteration 3:   log likelihood = -2209.0383
Iteration 4:   log likelihood = -2209.0383

Probit regression                               Number of obs   =       5580
                                                LR chi2(2)      =    1651.98
                                                Prob > chi2     =     0.0000
Log likelihood = -2209.0383                     Pseudo R2       =     0.2722

------------------------------------------------------------------------------
        FTTC |     Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         LLU |   1.322752   .0493094    26.83   0.000     1.226108    1.419397
  VirginMedia |   .532027   .0506591    10.50   0.000      .432737     .631317
       _cons |  -1.552825   .0330874   -46.93   0.000    -1.617675   -1.487975
------------------------------------------------------------------------------


. probit FTTC LLU VirginMedia  TotPrem

Iteration 0:   log likelihood = -3035.0264
Iteration 1:   log likelihood = -2050.3434
Iteration 2:   log likelihood = -2038.2775
Iteration 3:   log likelihood = -2038.2531
Iteration 4:   log likelihood = -2038.2531

Probit regression                               Number of obs   =       5580
                                                LR chi2(3)      =    1993.55
                                                Prob > chi2     =     0.0000
Log likelihood = -2038.2531                     Pseudo R2       =     0.3284

------------------------------------------------------------------------------
        FTTC |     Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         LLU |   .8419382   .0576673    14.60   0.000     .7289124     .954964
  VirginMedia |   .0954485   .0586845     1.63   0.104     -.019571     .210468
     TotPrem |   .0000739   4.24e-06    17.42   0.000     .0000656     .0000822
       _cons |  -1.636874   .0339221   -48.25   0.000     -1.70336    -1.570388
------------------------------------------------------------------------------


. probit FTTC LLU VirginMedia  TotPrem  PopDensity

Iteration 0:   log likelihood = -3018.3484
Iteration 1:   log likelihood =  -2023.611
Iteration 2:   log likelihood = -2010.8482
Iteration 3:   log likelihood = -2010.8189
Iteration 4:   log likelihood = -2010.8189

Probit regression                               Number of obs   =       5562
                                                LR chi2(4)      =    2015.06
                                                Prob > chi2     =     0.0000
Log likelihood = -2010.8189                     Pseudo R2       =     0.3338

------------------------------------------------------------------------------
        FTTC |     Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         LLU |   .8463818   .0580869    14.57   0.000     .7325337      .96023
  VirginMedia |   .0650537   .0604722     1.08   0.282    -.0534697    .1835771
     TotPrem |   .0000689   4.55e-06    15.14   0.000     .0000599     .0000778
  PopDensity |   .0034075    .001213     2.81   0.005       .00103    .0057849
       _cons |  -1.650656   .0342698   -48.17   0.000    -1.717823   -1.583488
------------------------------------------------------------------------------
```

```
. probit FTTC LLU VirginMedia  TotPrem  PopDensity  Median_Income

Iteration 0:   log likelihood = -3018.3484
Iteration 1:   log likelihood =  -2023.597
Iteration 2:   log likelihood = -2010.8031
Iteration 3:   log likelihood =  -2010.774
Iteration 4:   log likelihood =  -2010.774

Probit regression                               Number of obs   =       5562
                                                LR chi2(5)      =    2015.15
                                                Prob > chi2     =     0.0000
Log likelihood =  -2010.774                     Pseudo R2       =     0.3338


-------------------------------------------------------------------------------
        FTTC |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+-----------------------------------------------------------------
         LLU |   .8466772   .0580919    14.57   0.000     .7328191    .9605353
 VirginMedia |   .0626898   .0609877     1.03   0.304    -.0568439    .1822234
     TotPrem |    .000069   4.58e-06    15.08   0.000       .00006     .000078
  PopDensity |   .0033877   .0012149     2.79   0.005     .0010065    .0057689
Median_Income|   6.91e-07   2.30e-06     0.30   0.764    -3.82e-06    5.21e-06
       _cons |  -1.671276   .0769024   -21.73   0.000    -1.822002    -1.52055
-------------------------------------------------------------------------------
```

Annex D: BT Exchange Region Codes

Code	Region
CL	London Central
CM	Midlands Central
EA	East Anglia
EM	East Midlands
ES	Scotland East
LC	Lancashire
LN	London North
LS	London South
LV	Liverpool
LW	London West
MR	Manchester
MY	Yorkshire Mid
ND	North Downs
NE	North East
NI	Northern Ireland
NS	Scotland North
SD	South Downs
SL	Yorkshire South and Lincolnshire
SM	Midlands South
SS	Somerset and Avon
ST	South Coast
SW	Wales South
TH	Thames
WE	London West End
WM	West Midlands
WN	Wales North
WR	Westminster
WS	Scotland West
WW	Wales West

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Glossary

ASD	**Access Services Division** The Undertakings refer to Access Services as they were written prior to the launch by BT of Openreach to fulfil the undertakings related to Access Services.
BSA	**Bitstream Access** A high-speed access link from the telephone exchange to the customer's premises, which is then made available to third parties, to enable them to provide high speed services to customers.
CP	**Communications Provider** Generic term for a legal person providing a Public Electronic Communications Service or a Public Electronic Communications Network. This includes BT where relevant and includes Internet Service Providers.
EoI	**Equivalence of Inputs** The concept established by the undertakings in which BT provides, in respect of a particular product or service, the same product or service to all CPs (including BT) on the same timescales, terms and conditions (including price and service levels) by means of the same systems and processes, and includes the provision to all CPs (including BT) of the same commercial information about such products, services, systems and processes.
EoO	**Equivalence of Outcomes** The concept in which, in respect of a particular product or service, the wholesale input supplied to BT's own downstream division(s) is equivalent to the comparable product or service supplied to other CPs but not necessarily supplied in an identical manner.
FTTX	**Fibre to the X** A generic term for any broadband network architecture using optical fibre to provide all or part of the local loop used for last mile telecommunications. The term is a generalisation for several configurations of fibre deployment, ranging from FTTN (fibre to the node) to FTTH (fibre to the home).
HFC	**Hybrid fibre-coax** A broadband network that combines optical fibre and coaxial cable. It has been commonly employed globally by cable television operators since the early 1990s.
KPI	**Key Performance Indicator** Something which is measured and used as an indicator of performance against a defined target.
LLU	**Local Loop Unbundling** The mechanism by which CPs other than the incumbent can gain wholesale access to the incumbent's metallic local access network.
Local	The physical link or circuit that connects the customer premises to

Loop	the local telephone exchange. It is sometimes also referred to as the "last mile".
MPF	**Metallic Path Facility** A circuit comprising a pair of twisted metal wires between an end user's premise and a main distribution frame that employs electric, magnetic, electromagnetic, electrochemical or electromechanical energy to convey signals when connected to an electronic communications network.
MSAN	**Multi-Service Access Node** An integrated broadband system delivering voice, video and data services to business and residential users. MSAN line cards provide connectivity to broadband customer premises equipment (CPE), seamlessly aggregating xDSL and PON traffic in a single design.
NGA	**Next Generation Access** A significant upgrade to the Broadband available by making a step change in speed and quality of the service. This is typically thought of as asymmetrical with a download speed of 24Mb plus and a fast upload speed.
NGN	**Next Generation Network** A packet-based electronic communications network which is able to provide electronic communications services and to make use of multiple broadband and quality of service-enabled transport technologies, and in which service-related functions are independent of underlying transport-related technologies.
Openreach	The division created by BT to fulfil the undertakings related to Access Services. See: http://www.openreach.co.uk for more information.
WLR	**Wholesale Line Rental** Service offered by BT Wholesale to other service providers allowing them to offer their own branded telephony service. See: http://www.btwholesale.com for more information.
xDSL	**Digital Subscriber Line** The predominant technology for the provision of broadband services on BT's access network of which there are a number of varieties. The most prevalent variety is Asynchronous DSL, which allows speeds of up to 24 Mbps.

This glossary is adapted from Ofcom 2005.

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