Exclusivity, Bundling and Switching in Communications Markets

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Abstract

This thesis empirically analyses two case studies of markets associated with high-tech goods or services. In both cases the analysis includes an extensive literature review and in-depth study of market characteristics. These serve to inform the investigations and also provide technical background.

The first part of the thesis examines the international distribution of the Apple iPhone and the incentives of the manufacturerto distribute the product exclusively to mobile network operators. The study uses a novel application of a double-hurdle model to analyse a cross-sectional dataset of 187 countries featuring industry-specific and demographic variables drawn from both off-the-shelf sources and from an analysis of several hundred individual sources of evidence. The results show that the mechanisms determining the duration of exclusivity agreements differ from those factors determining their initial imposition. In addition, it is shown that the level of competitiveness and concentration in the downstream market are significant determinants of both the decision to sell in a country and the duration of any exclusivity agreements. The presence of competing technological standards is also shown to result in longer periods of exclusivity indicating slower diffusion of the product in these countries.

The second part of the thesis empirically examines the incentives of individuals to switch provider of their household communication services in the presence of bundling of services. The study uses a random effects probit method to analyse survey data of 2,871 households' communication subscriptions. The results indicate that when service subscriptions are bundled there is a significant reduction in the likelihood of an individual switching their provider. Furthermore, this effect is intensified when the bundle includes services in which the provider specialises.

The results of both studies are consistent with economic predictions of, respectively, the use of key differentiators by firms to gain competitive advantages, and the use of bundling to create switching costs for consumers. Both studies represent significant contributions to the study of vertical restraints, and consumer switching behaviour.

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Thank you.

Foreword

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"Technology... is a queer thing. It brings you great gifts with one hand, and it stabs you in the back with the other."

- C.P. Snow, New York Times, 15 March 1971

In the past decades the world has experienced seismic changes in the way humans interact with one another and engage with the world around them. Driven by exponential advances in technology we are now able to consume information in volumes that were previously impossible. We communicate in ways that were previously unimaginable, or otherwise the stuff of science fiction. Even within the lifetimes of young people, the world has evolved, and continues to evolve with little sign of abatement.

This constant state of change in which we exist is often coined the 'information' or 'digital' revolution. In many senses it is more revolutionary than the industrial revolution of the 18th century. Though the industrial revolution was limited to a handful of the world's economies, it shaped the development of the world. Indeed, the so-called industrial revolution is still to reach some corners of the world. Our information revolution, however, is not limited by such geographical boundaries, and may yet shape the global society beyond to an extent which dwarfs earlier developments. Even within the most developing of countries technology is permeating and changing the lives of the worlds poorest by enabling new avenues of commerce and communication.

While these leaps in technology come bearing great gifts, they are also accompanied by new challenges. These are challenges for firms, individuals, and those organisations charged with protecting the interests of individuals.

Technological change has changed immeasurably the way in which commerce is carried out, and the goods and services which people demand. The insatiable appetite for newer and better products, coupled with the ways in which we wish to purchase means that firms must continually evolve and adapt. Product innovation is a contin-

uous process, driven by fierce competition, with firms trying to find a niche market or novel delivery method which will ensure their survival. High profile cases of 'fallen giants' such as Nokia, or high street chain Woolworths, illustrate keenly that historical significance represents no barrier to failure.

The rate of change of technology also presents difficulties for consumers. Rapid advances mean that knowledge of products and markets is rapidly out of date. Swamped by the complexity of new products and channels of delivery, decision making becomes ever more precarious and more choices made under uncertainty.

The increased complexity of technology creates challenges for regulators and authorities tasked with the protection of consumers. The relentless advances require the understanding of the economic effects of an increasing range of practices by firms, and the ability to identify the benign from the pernicious.

This thesis is set against this backdrop and explores two cases which highlight the uncertainty inherent in the current climate.

In the first part the thesis studies distribution strategies made by, Apple, the manufacturer of a high-tech product. It examines how competitive restraints and the environment into which it sells the product determine its decision to supply exclusively to particular downstream firms, and the conditions under which this can break down.

The second part of the thesis investigates the challenges faced by consumers in their purchases of communication services. The advances in both the way with which individuals consume information, and the information individuals choose to consume, means that household subscribe to an increasing range of technologies. The way in which these are delivered is also evolving, resulting in complexity in prices and effects which impact on consumers' ability to make optimal decisions.

The empirical analysis of both the above cases examines the challenges faced by parties in the current environment of technical progress. Each study is accompanied by a technical chapter outlining the main characteristics of the technology and industry and a review of the relevant literature.

Entry and Exclusivity: The case of the iPhone

Introduction

The marketing of the Apple iPhone between 2007 and 2010 involved a strategy of the imposition of conditions upon the mobile network operators that were to sell the device to final consumers. A key component of this strategy was the allocation of exclusive distribution agreements for distributors in some countries. Furthermore, where these restraints were imposed, these varied in duration - ranging from months up to several years.

There exists a well developed literature discussing the theoretical motivation for the implementation of vertical restraints, specifically concerning exclusive territories. However, there has thus far been little attention paid to dynamic applications of exclusive distribution or the optimal duration of any agreements.

This chapter has several main objectives. The first is to test the understanding of the conditions under which exclusivity agreements are entered into. The second is to investigate the drivers of duration of such agreements, specifically the case where these deviate from the drivers of the initial decision to supply exclusively. In a separate investigation the current chapter also investigates factors which determined those countries in which agreements were made to sell the iPhone.

In achieving its aims the distribution of the iPhone is first examined using a custom dataset which demonstrates the patterns of distribution which existed. This is followed by a review of the applications of, and policy approach toward, vertical restraints, and an analysis of the literature concerning territorial exclusivity. An empirically informed overview of the market structure of the mobile phone industry follows which sets out context, stylised facts, and key technical information to inform the investigation. The chapter concludes with an empirical investigation in which the distribution of the iPhone is analysed using a cross-sectional dataset featuring key variables informed by the literature, and which reflect the prevailing characteristics of mobile telecommunications.

1. Vertical Restraints and iPhone Distribution

The early distribution of the iPhone was subject to exclusive distribution agreements of varying duration in a number of the countries in which it was sold. The following section sets out this pattern of distribution which was observed during the initial years of the iPhone's availability. The section contains some technical terminology which is addressed in greater detail in section 2.1. The following sections also introduce vertical restraints, this is followed by a review of the existing literature focussed on exclusive distribution.

1.1. The Distribution of the iPhone

The iPhone, which was launched in 2007, was electronics manufacturer Apple's first foray into the production of mobile telecommunication handsets. Previously the firm had been identified with, amongst others, home computers and portable personal music players. The iPhone featured a relatively novel touch-screen user interface, an aesthetic design which was very similar to Apple's other successful products, and heavily promoted the firm's online application store[1] which supplied small inexpensive software add-ons for the handset. In the final quarter of 2012 the iPhone accounted for 9.2% of global handset sales by volume[2].

The data used in this overview analysis is sourced from a dataset constructed by the author. This dataset contains information on the countries in which the iPhone launched, the network operators which sold the device, and the dates that each operator started selling. The dataset was constructed over a prolonged period through an exhaustive analysis of press releases, industry news, and local news articles; in

[1] Which drew heavily on the firm's previous success at selling music online.
[2] Gartner [2013]

total around 300 separate sources were used. The dataset and its source material is reproduced in appendix B. A detailed description of the data gathering is in section 3.2

The marketing of the iPhone was different from that of many other handsets. Where it is common practice for mobile phone handsets to be subsidised when purchased with a fixed term network subscription, the iPhone was generally less subsidised than rival manufacturers' handsets. Apple also proceeded with a strict annual schedule for the updating of the hardware, producing four varieties of handset between 2007 and February 2011; figure 2.5 in section 2.4 (page 33) shows that some other manufacturers produced hundreds of handset varieties in the same period.

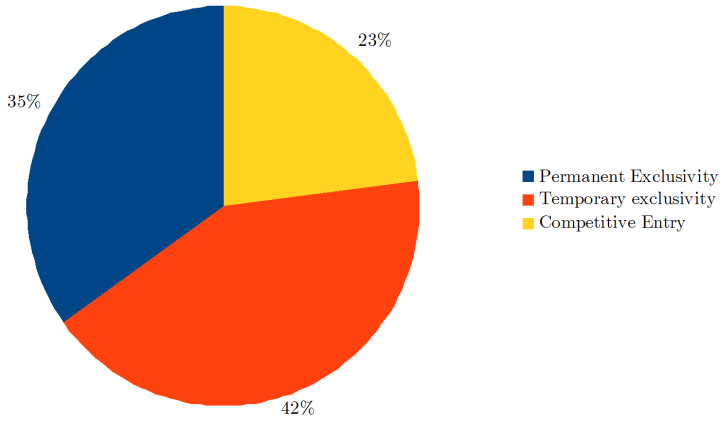

Figure 1.1.: Distribution strategies

Source: Author's own research

In addition to these strategies, the distribution of the iPhone followed a pattern of distribution where it was sold exclusively by a single network operator in some territories. Of these exclusivity agreements, some were temporary and characterised by differing durations in different territories, while others were on-going. Although exclusive distribution of premium handsets has been selectively employed for several years[3], the popularity and profile of the iPhone has enabled the collection and analysis of high quality data concerning the pattern of its distribution. This has enabled the present analysis of the choice of countries in which the phone was sold, and the determinants of exclusivity agreements and their subsequent duration.

[3]Zhu et al. [2011] offer a short overview of exclusivity agreements in the US.

Figure 1.1 indicates the distribution of agreement type across territories where the iPhone has been made available since 2007. It shows that exclusivity agreements were favoured over having competing retailers, and that in roughly half of these cases this exclusivity was temporary.

In addition to the differences in exclusivity, the launch of the iPhone was staggered; it did not simultaneously launch in all countries. Figure 1.2 illustrates the pattern of distribution across different time periods; *Exclusive* indicates that a firm in the country had a period of exclusive distribution, while *Competitive* indicates that more than one firm in that particular country simultaneously sold the iPhone at launch.

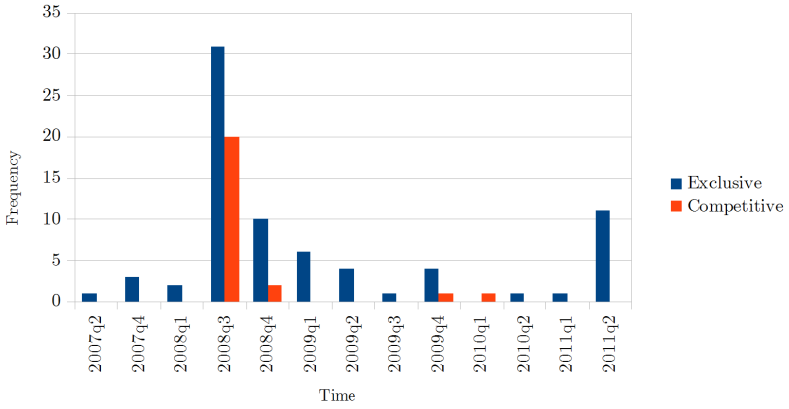

Figure 1.2.: Exclusive versus competitive distribution of iPhone at launch

Source: Author's own research

Figure 1.2 shows the general trend in favour of exclusivity and is dominated by a spike in the third quarter of 2008[4]; this quarter represents a period of international roll-out of the iPhone. Although the early distribution was dominated by exclusivity agreements, they still continued to be entered into after 2008.

Figure 1.3 indicates that, in addition to the staggered entry and selective exclusiv-

[4]The second spike in 2011 is largely result of the simultaneous introduction of the iPhone to a number of small Caribbean countries (including, amongst others, Anguilla, Antigua and Barbuda, and St Lucia).

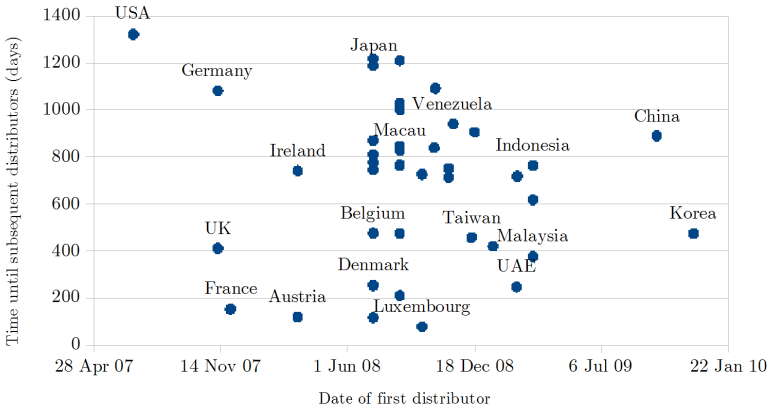

Figure 1.3.: Date of first iPhone distributor and time until next entrant

Source: Authors own research

ity, the duration of the exclusive distribution agreements also varied between different countries. Some, such as Germany or the US, did not have a second vendor of the iPhone for around three years from the date of the original exclusive operator, while others had a second vendor of the iPhone market after several months. This variability is present even between countries where the iPhone was launched in a similar time window.

The present investigation seeks to explain what determined these patterns of exclusivity, and what determined the choice of countries. The chapter continues by examining the motives for, and policy approach toward, vertical restraints.

1.2. Vertical Restraints

Interactions between firms take place either horizontally between firms at the same stage in the vertical supply chain, or otherwise vertically between firms at different, usually contiguous, stages in the production process. The firm's attempts to achieve its objectives (classically viewed as - but not limited to - profit maximisation), given the nature of competition with horizontal rivals, often conflicts with the incentives of other firms in the vertical chain.

In conventional analysis of horizontal competition firms take their costs, level of demand, and mode or intensity of horizontal competition as a given and maximise their profits based upon these constraints. Often firms act without considering the effect that their actions have on the combined profit of the vertical structure as a whole. Pricing decisions at one point in a vertical chain can affect pricing decisions (and thus quantity of the product demanded) at other levels. The failure of the vertical chain is typified in the theory of double marginalisation outlined by Spengler [1950] where successive self-interested profit-maximising monopolists in vertical chain disregard the interdependencies between theirs and others pricing decisions resulting in lower combined profit than would be achievable through co-ordination or integration.

In the vertical chain some firms produce and sell intermediate goods or service which are used as inputs in the production of other other products. Katz [1989] remarks that because, unlike in final goods markets where individual purchases are made by a large number of buyers, transactions of intermediate goods are characterised by sizeable orders made between large buyers and sellers, each with divergent incentives. In this setting the assumption of a simple linear price (as assumed in final gods markets) is unrealistic and firms often employ more sophisticated pricing mechanisms.

Such sophisticated pricing schemes are an example of vertical restraints; a suite of practices that can be used one firm to influence the decisions of other firms in the supply chain. These are typically employed to increase the profit of the vertical chain but can be used to influence other objectives such as innovation. Vertical restraints are so-called because they are rules or conditions that restrain the behaviour of firms to a particular set of actions. Rey and Vergé [2003] outline the most common restraints which include the imposition of controls on final selling price, limitations on quantity, restrictions on territory in which a firm can operate or sell, or conditions on the supply

of inputs; though any rule which limits the behaviour of a vertical partner is a vertical restraint. Restraints are furthermore often characterised by penalties imposed for non-compliance.

Other deviations from simple linear pricing such as the imposition of non-linear tariffs or conditional wholesale discounts are considered by some to be vertical restraints since they can influence the decisions of the downstream partner. These differ however in that there is no defined punishment for non-compliance unlike the case of vertical restraints – this is reflected in the approach of antitrust authorities vis-a-vis restraints where penalties can be imposed.

1.2.1. Exclusivity Clauses

One particular set of vertical restraints imposed on firms involves restricting the number of firms in the vertical chain with which that particular firm can deal; these are termed exclusivity agreements. There are two types of exclusivity agreement which may be implemented by an upstream supplier:

Exclusive dealing requires that the retailer only purchase a relevant input from the particular supplier at the expense of its rivals. This can have the effect of foreclosing the demand for the rival of the upstream firm, but may also have efficiency motives if the upstream firm has economies of scale in the cost of production. The exclusionary nature of exclusive dealing contracts is discussed at length in both Aghion and Bolton [1987] and Rasmusen and Ramseyer [1991].

Exclusive supply (also known as exclusive distribution or territorial exclusivity) describes the situation where the final market is segmented and a certain portion allocated to specific downstream retailers. This can be either in terms of geographical area, or different customer types (where it is possible to discriminate between different groups of consumers). Such market segmentation, by allocating a monopoly position in a certain segment, can have (amongst other outcomes) the effect of reducing downstream intra-brand competition. This reduces the extent to which downstream firms compete against each other to sell products produced using the input of the upstream firm.

Territorial exclusivity agreements are relatively common especially amongst franchis-

ing organisations where the franchiser will allocate the franchisee a certain catchment area; in effect guaranteeing the downstream partner a certain level of demand.

1.2.2. The policy Approach to Vertical Restraints

The approach of policy makers toward vertical restraints (and vertical agreements in general) is different to that for horizontal agreements. Horizontal agreements are per se illegal and assumed to be anticompetitive, this is not the case for vertical restraints. Some vertical agreements can be shown to increase consumer welfare and, as such, some types of vertical restraint are viewed on a case by case basis. Notably exclusive distribution agreements are illegal in some countries, notably where a dominant firm restricts access to an essential input.

The contrasting argument for a more permissive stance toward vertical restraints is reflected in the attitudes of antitrust authorities in both Europe and the US – where policy has veered between per se prohibition of all restraints (prior to 1999 in Europe and 1985 in the US), and the lenient scenario whereby most vertical restraints are freely allowed (between 1985 and 1993 in the US). The introduction in Europe of Commission Guidelines on Vertical Restraints, and the abolition in the US of the 1985 Vertical Restraints Guidelines meant that both territories now employ a rule-of-reason approach except in the case of resale price maintenance (price setting) or mandated minimum prices. However, even to this effect, Lafontaine and Slade [2005] note that not only are the effects of price controls replicable through a suite of alternative restraints, but moreover that price controls (like any other vertical restraint) can be used to enhance efficiency in a way which does not harm consumers.

Vertical restraints pose a problem for anti-trust where they either facilitate collusion in a given horizontal market, or otherwise result in partial or complete foreclosure of related markets. Rey and Vergé [2003] highlight cases in the EU in which Nintendo (2003) and Grundig (1966) were both fined for restricting downstream competition by restricting parallel trade – placing cross-border resale restrictions on their products. The authors also highlight the case of Pronuptia (1986), censured for its use of resale price maintenance, which was found to have facilitated collusion between its branches.

1.2.3. Defining Apple's Restraints

It is not possible to observe the contractual terms which were agreed between Apple and network operators, however it *is* possible to observe the outcome of those contracts. To this effect figure 1.4, which offers a stylised depiction of the iPhone distribution, indicates that an exclusivity agreement exists between manufacturer *M1* and operator *R1* – the direction of this exclusivity determines the appropriate focus for the analysis.

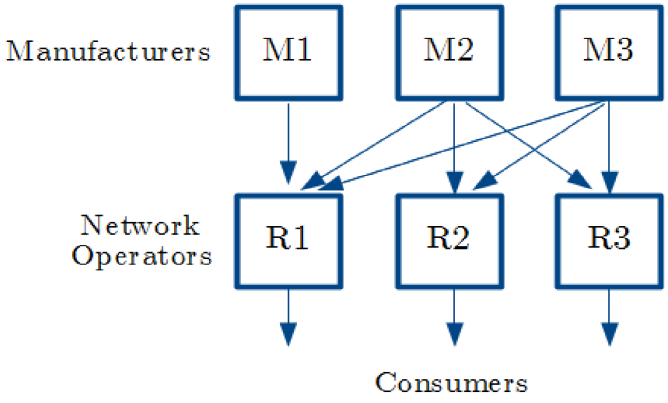

Figure 1.4.: Stylised exclusivity arrangements

The exclusivity agreement that exists between *M1* and *R1* does not preclude *R1* from carrying substitute products from other firms (although *M1* only deals with *R1*, *R1* deals with both *M2* and *M3*). Although the substitutability of different mobile phones is not a trivial assumption, being that they are differentiated products, firms which sold the iPhone continued to sell phones made by rival manufacturers. It would be possible to narrow the market definition to that of just the iPhone, in which case a 'de facto' exclusive dealing arrangement existed (being that Apple was (and is) the monopoly supplier of the product). However, the definition of the iPhone as one product in a broader set of mobile telephones eliminates the exclusive dealing theory and leads instead to the view that this is a case of exclusive distribution.

The exclusive distribution restraint imposed by Apple determines the appropriate literature and theories relevant to the analysis of the conduct; this is a case of an upstream firm choosing only to deal with a single downstream firm. Theories relating to exclusive dealing (such as Aghion and Bolton [1987]) are not appropriate since there

are no clear limitations imposed on downstream firms' dealings with other upstream rivals. In the following sections both the theoretical and empirical literature relating to exclusive distribution is reviewed in order to understand those factors which are likely to be influential in the decisions of the upstream firm to impose a territorial exclusivity restraint.

1.3. Existing Research into Exclusive Distribution

The scope of this part of the thesis is in the understanding of exclusive distribution restraints imposed on sellers of the Apple iPhone. The following review focusses on the broad literature, both theoretical and empirical, which investigates the use of exclusive distribution agreements. The theoretical literature is broadly focussed on two main themes; exclusivity restraints to resolve divergent incentives in intra-brand competition, and exclusivity as a means to soften upstream competition in the presence of intra-brand competition. The empirical literature is more varied in scope and draws relevant conclusions from a range of different real-world investigations.

This chapter is focussed on the case of intra-brand competition and thus the main literature review is focussed in this area. There are however important contributions from the literature concerning inter-brand competition and so this literature is briefly considered. The findings of the empirical literature are benchmarked against the theoretical literature and considered in the context of the present investigation.

1.3.1. Intra-brand competition

The literature on intra-brand competition focusses on the case where an upstream firm faces no upstream rivals and sells intermediate products to downstream firms. In this case the upstream firm has the ability to impose a range of restraints to influence the decisions of downstream firms and better align their incentives with its own.

The case that an upstream firm does not impose restrictions on the downstream market does not imply that the downstream market is otherwise competitive. On the contrary, it is downstream market imperfections which motivate the upstream firm to implement restraints.[5] In one of the earliest examples Spengler [1950] lays the foundation for the study of vertical restraints through the introduction of the vertical externality inherent in vertical chains. The author illustrates the failure of linear pricing in successive markets to deliver the same profit as would be achievable by a vertically integrated monopolist. In this instance attempts to profit maximise at successive levels of a vertical chain, given the input costs faced by firms, results in final prices higher

[5] A standard result in many of the following papers [Mathewson and Winter, 1984; Rey and Tirole, 1986] is that when a downstream market is perfectly competitive, this competition eliminates downstream intra-brand profits and enables the upstream firm to secure the vertically integrated profit by setting a linear wholesale price equal to the monopoly final price.

than the equivalent monopoly level. This is 'double marginalisation' and is key in the argument that vertical restraints can be welfare enhancing.

Two key papers which both examine the rationale for the implementation of different restraints are Mathewson and Winter [1984] and Rey and Tirole [1986]. Both seek to explain the use of restraints in a vertical setting with a single upstream monopolist selecting how to contract with one or more downstream agents.

In Mathewson and Winter [1984] the authors propose the minimum set of vertical restraints, including exclusive distribution, which can be used to elicit the equivalent vertically integrated monopoly profit benchmark (or similarly a single upstream firm selling into a perfectly competitive (free entry) retail market). The authors specify a circular model of downstream competition where retailers must advertise their product across an endogenously chosen radius of influence. Under attempt to use simple linear tariffs Mathewson and Winter [1984] highlight three externalities: double marginalisation; horizontal pricing and undercutting; and information (or advertising) spillovers.

The double marginalisation effect occurs because upstream firms are limited to linear pricing. The upstream firm aims to make profit by setting a wholesale price in excess of cost; as a result downstream final prices to consumers are too high. This finding matches the double marginalisation effect of Spengler [1950].

Horizontal externalities in the Mathewson and Winter [1984] model stem from adverse selection on the part of the downstream firms. The information spillover means firms do not fully appropriate the full benefits of their advertising effort and consequently advertise too little. The price externality, given the presence of competition and negative cross-price elasticity, prompts firms to price too low in order to attract marginal customers which would otherwise be served by a downstream rival. This effect is known as the upstream firm cannibalising the demand for its own product.

Mathewson and Winter [1984] show that when there is no advertising spillover the use of a multi-part tariff, in conjunction with closed territorial distribution (retailers are not competing to attract customers from rivals' territories), eliminates both horizontal and vertical externalities. However, with spillovers in advertising, despite the lack of horizontal price externality, the retailer still does not appropriate the full benefit of their advertising and thus advertises too little. In this case only the guarantee of

a retail margin through price controls can incentivise the correct amount of advertising.

Implicit in Mathewson and Winter [1984] is the assumption that, while selling and buying activity can be segmented into closed territories, advertising effort cannot. The implementation of the authors' interpretation of closed territory distribution does not appropriate the full 'integrated' level of profit because of the advertising informational externality, it *does* solve the horizontal pricing externality. Thus exclusive distribution, when combined with a suitable two part tariff, results in a superior outcome to that which would be elicited in its absence.

The advertising dilemma in Mathewson and Winter [1984] is one of adverse selection; competing firms do not advertise optimally because they believe that they will not appropriate the full benefits of their advertising. The dilemma is similar to Lafontaine and Slade [2005] in their approach. These authors cite a separate form of adverse selection as the cause for the implementation of vertical restraints; where upstream manufacturers require downstream dealers to make costly investments. The allocation of an exclusive territory can guarantee a downstream firm a minimum level of demand, thus removing the risk from their investment and aligning the interests of both up- and downstream parties.

A different approach to Mathewson and Winter [1984] is used in Rey and Tirole [1986] which seeks to understand the logic underlying the use of particular vertical restraints using a simpler vertical arrangement. Their model has a single upstream monopolist, but with a downstream under which firms compete in price along a standard Hotelling line.[6] The authors focus on the comparison of two types of restraint; resale price maintenance (mandating downstream prices) and exclusive territories.

A key feature in Rey and Tirole [1986], which is utilised throughout much of the subsequent literature, is the principal-agent nature of a vertical retail chain. Often information is decentralised – an upstream manufacturer may not have immediate knowledge of the downstream market conditions. Under such conditions attempts to impose vertical restraints upon downstream firms, based upon assumptions of demand or supply conditions, may not result in extraction the full potential profit. Vertical restraints imposed by an upstream firm may even be rejected by downstream firms. Rey and Tirole

[6] For the bulk of the analysis the authors specify the Hotelling travel cost to be zero – resulting in a case of pure undifferentiated Bertrand price competition

[1986] model this uncertainty across two variables in the model: demand uncertainty; and uncertainty in the unity cost of sale faced by a downstream firm. This uncertainty introduces a participation constraint on the downstream since there will be a subset of contractual restraints which will leave downstream firms with negative profits.

When considering which, if any, restraint to impose, when downstream firms are risk averse the manufacturer must consider insurance properties to ensure the participation of the downstream partner. Resale price maintenance is better at dealing with *demand* uncertainty while allocation of an exclusive territory (in addition to a two-part tariff) yields higher upstream profit than resale price maintenance under *cost* uncertainty. With risk aversion, however, a competitive downstream market delivers better outcomes than either. When the stipulation that retailers are risk averse is relaxed and they become risk neutral (but still undifferentiated), then decentralisation of final pricing decisions by granting of an exclusive territory with a two-part tariff leads to a superior outcome.

This illustrates the standard result that when imperfections are introduced into the downstream market, specifically when retailers are differentiated, the effectiveness of competition to resolve vertical issues is diminished.

O'Brien and Shaffer [1992] reach the same conclusion as Mathewson and Winter [1984] that in order to achieve the first-best profit the upstream firm must eliminate the horizontal pricing externality. Furthermore, the authors show that this can be achieved either through resale price maintenance (which they show to eliminate all vertical and horizontal externalities), or otherwise through the use of exclusive distribution.

The O'Brien and Shaffer [1992] result is contingent upon the non-violation of the territorial exclusivity agreement. Specifically the authors show that it must not be in the upstream firm's interest to tacitly encourage this violation. In the arrangement of an exclusive territory there exists a moral hazard problem in that, once a two-part contract is agreed, the upstream firm has the incentive to 'sell the market a second time'. This results in negative profits for the firm which agreed the initial contract. The credibility issue inherent in the establishment of exclusive territories also informs the analysis of Boyd [1993], discussed in section 1.3.3 in relation to the empirical literature.

There is a separate moral hazard problem in that, once a contract has been agreed, a downstream firm may have the incentive and ability to profitably sell outside their allotted territory. This results in rationing of a fixed quantity across two territories rather than one. The governance of exclusive territories is examined by Dutta et al. [1994] who propose a model similar to that of Rey and Tirole [1986] where the upstream monopolist sells an input to two downstream competitors using a two-part tariff and allocates to each an exclusive territory. Similarly Dutta et al. [1994] also include uncertainty in both the cost of sale for downstream firms and the level of demand. As per the earlier paper, this offers the upstream firm the incentive to decentralise decision making. In addition to a uniform marginal cost of sale for downstream firms, the authors also also propose that firms can engage in costly demand enhancing activities.

Dutta et al. [1994] find that in equilibrium the upstream firm tolerates a certain degree of 'bootlegging' (the sale by one downstream firm into the rival's territory). A small amount of bootlegging is preferable to the case in which no territories are allocated, or where there is zero enforcement of the territories. Both of these result in full intra-brand competition with zero investment in demand-inducing services. The authors also show that as demand becomes more sensitive to reseller services, the incentive to strictly enforce this bootlegging limit increases to ensure that firms do not 'cheat' on the agreement and bootleg more.

This literature has demonstrated that intra-brand retail competition may not elicit the first-best profit for the upstream firm. In this instance vertical restraints, specifically exclusive distribution, can be used to remedy extant issues of moral hazard and adverse selection and align incentives of up- and down-stream firms.

1.3.2. Inter-brand competition

The literature mentioned thus far primarily concerns itself with the case of intra-brand competition and the restraints used by an upstream monopolist in order to maximise profits given different configurations of downstream competition. The introduction of inter-brand competition means an upstream firms must consider not only the sales of their own products, but the strategies of their upstream rivals. Upstream firms face the choice of not only whether to distribute through a single downstream retailer, but also the decision of whether to use a common downstream agent with their upstream rival.

Because the current investigation is focussed on inter-brand competition only the key findings of the inter-brand literature are outlined in the following passages.

Rey and Stiglitz [1995], Lin [1990], and O'Brien and Shaffer [1993][7] all indicate that competing upstream retailers prefer to deal exclusively with their own downstream firms – avoiding having a common downstream agent. By minimising downstream inter-brand competition this softens the competitive constraint they impose on one another. Focussing on the softening of upstream competition, Saggi and Vettas [2002] find that upstream firms choose to exclusively distribute; where firms deal with multiple downstream agents this induces the rival to behave more competitively.

A feature common to all the literature above (both intra- and inter-brand) is that upstream firms make take-it-or-leave-it offers to downstream agents. Trivedi [1998] and Dobson and Waterson [1996] both examine the case where power is more balanced and consider the incentives for downstream firms. Both papers indicate that in some circumstances a single downstream firms prefers to carry products from all upstream firms.

Subramanian et al. [2012] is relevant to the current paper as the authors specifically examine exclusivity agreements with respect to the Apple iPhone and mobile telecommunications. Like the above papers, Subramanian et al. [2012] examine the case where an exclusivity agreement is in the mutual interests of both the upstream telephone manufacturer and the downstream network operator.

The authors, like Rey and Stiglitz [1995], utilise a simple two-upstream, two-downstream model, but where downstream firms are differentiated according to a uniform interval of consumers – intended to capture elements of quality differentials such as difference in signal strength. The authors also specifically model features of mobile telecoms such as consumer heterogeneity in the amount they use their phone. Like Rey and Stiglitz [1995], Subramanian et al. [2012] show that under certain scenarios a handset manufacturer may choose exclusivity in order to induce a rival to increase its wholesale prices, thus softening competition. However, unlike that paper, the authors also focus on mutual incentives, as opposed to a take-it-or-leave-it approach. Subramanian et al. [2012] find that network operators may find it advantageous to enter exclusivity since limiting the available handsets to their rivals may raise their rival's input costs.

[7] O'Brien and Shaffer [1993] is a critique of Lin [1990] and utilises the same model.

The findings above occur under specific bounds of relative quality between handsets. Subramanian et al. [2012] also find that likelihood of exclusivity agreements is increasing in the propensity of consumers to use wireless services (the baseline usage by individuals), increasing in the overall quality of the network with the exclusivity agreement, but decreasing in the degree of handset differentiation[8].

1.3.3. Empirical literature

In addition to the theoretical literature there exists an empirical literature which examines the imposition of exclusive territories. This is mainly split into two themes: the welfare effects of exclusivity restraints; and the motivation for strategic delegation of downstream pricing decisions versus vertical integration.

Sass and Saurman [1993] study the relationship between brewers and beer wholesalers and the impact on price of different state laws concerning territorial exclusivity. Using a cross-section of twenty four states Sass and Saurman [1993] find that exclusivity agreements serve to increase prices, indicating the expected effect of reduced intra-brand competition. The authors also show, however, that where exclusive territories are mandated, the estimated demand for beer is higher; suggesting that, as per Lafontaine and Slade [2005], territorial exclusivity can provide guarantees to firms which incentivises otherwise costly sales effort.

Though focussed on vertical integration, Lafontaine and Slade [2007] shares many features in common with the current as it investigate upstream firms' incentives to impose vertical restraints. The authors identify the key drivers of the vertical integration decision from a theoretical model and review the prevailing empirical literature to ascertain whether predictions made in theory are also supported by the empirical evidence.

Instead of using a cross sectional analysis Brenkers and Verboven [2006] utilise a natural experiment to estimate the welfare effects of a change in legislation toward vertical restraints. The case studied involves the sale of cars in the EU where in 2002 it was proposed to abolish rules permitting territorial exclusivity and restrict manufacturers

[8] Understandable since increasing the degree of differentiation, reduces the substitutability of products - meaning that handset wholesale prices in absence of exclusivity are higher and less reactive to the prices of the rival.

to policies which aimed to intensify intra-brand competition and reduce cross-border price discrimination. The authors applied the observed data to a nested Logit model to estimate a demand function, then utilise the observed coefficients to estimate welfare post-liberalization. Brenkers and Verboven [2006] find that the abolition of territorial exclusivity which would permit firms to freely compete would deliver welfare gains of between 1.6 billion and 8 billion Euros. The authors remark, however, that these figures exclude the potential efficiencies which can be achieved through vertical co-ordination such as the incentivisation of sales effort.

Zhu et al. [2011] seek to measure the welfare consequences of the long-term exclusivity agreement between Apple and network operator AT&T for the distribution of the iPhone in the US. Unlike the present investigation the authors do not examine the motives for the exclusivity agreement. The authors utilise research data on mobile telephone use from 2007 and 2008 to estimate a random coefficient Logit model for common handsets and contract subscription bundles in order to estimate the demand for mobile services. The authors next estimate the supply function using utilising wholesale and final consumer prices. By developing a counterfactual analysis based upon the estimated margins at operator and manufacturer level, the authors estimate that the reduction on intra-brand competition created by the exclusivity of the iPhone resulted in a welfare loss of between $210 million and $326 million.

Boyd [1993] is a rare paper which theoretically and empirically examines the motivation of an upstream firm to engage in exclusive territorial distribution. In this instance the author uses litigation cases based around vertical restraint of trade to determine whether an upstream firm imposed resale price maintenance, exclusive territories or both on their downstream retailers. Boyd [1993][9] observes that, like Rey and Tirole [1986], resale price maintenance and exclusive distribution may not be perfectly substitutable. The author uses the theoretical example of repeat purchase goods which may have quality or functionality revised often relative to purchase (a durable electronic good for example), and the opposite where revised functionality may occur rarely relative to purchase (petrol or any other consumable). In the latter case, once an initial purchase is made then a consumer is aware of attributes and thus has no need of sales effort – resulting in reduced derived demand. For these products a manufacturer prefers to employ territorial exclusivity even with an associated double marginalisation. Where technology changes with each purchase, and purchasers purchase their first unit from

[9] And also Boyd [1996].

a high sales effort outlet, resale price maintenance is preferred as retailers compete in sales effort to attract customers. The empirical analysis in Boyd [1993] also bears this prediction out – indicating that in routine repeat purchase good cases the prevalent vertical restriction is territorial exclusivity.

1.3.4. Contribution

There is a wealth of theoretical literature which focusses on incentives for the imposition of various vertical restraints. The literature which considers intra-brand competition heavily focusses on the use of restraints to resolve divergent incentives at different stages of production. The inter-brand literature instead examines the use of restraints to soften competition between upstream firms. Also within the scope of inter-brand literature is that which examines not just restraints imposed upon downstream firms, but also the case where they are mutually beneficial. Both branches of the theoretical literature serve to inform variables which can be included in empirical investigation, as per Lafontaine and Slade [2007].

The empirical literature has taken several approaches, focussing on both welfare effects and incentives. However there are few examples where the incentives for the imposition of exclusive distribution are empirically examined, perhaps only Boyd [1993].

The present investigation, with its econometric approach, improves the understanding of exclusivity in a number of ways. It adds to the limited empirical literature on determinants of exclusive distribution, also including an analysis of entry. More crucially, this paper is the first paper which questions the optimal duration of exclusivity contracts from either theoretical or empirical spheres. In doing so, the results of the paper suggest that the explanation of duration as some extension of the process which determines initial exclusivity is flawed.

2. The Mobile Telecommunications Industry

The empirical study of the distribution of the iPhone requires an understanding of the product and the environment in which it was sold. As such the following sections describe in detail the nature of the product, the industries which provide these goods and services, and the characteristics of the markets through which mobile telecommunications services and associated equipment are sold. A specific function of these sections is also to introduce technical concepts and terminology which are used throughout the remaining chapters.

2.1. A Background to Mobile Telecommunications

The development of current mobile phone technologies first began in the 1960s with the development of early cellular systems which for the first time, though experimentally, enabled large numbers of users to connect to the same network [Grüber and Verboven, 2001]. Although commercial cell-based systems began to launch in the 1980s there were many incompatible technologies in use, each championed by different countries; this meant that travelling between different countries with a single mobile phone was impossible when it was first introduced.

In 1992 European countries began to implement a uniform technology for the broadcast of mobile phone signals known as GSM.[10] The use of a common technology meant that all European networks operated using a single technological standard – allowing a subscriber from one country to make and receive calls while 'roaming' in other European countries. The technology also made more efficient use of radio frequencies; enabling many more users to simultaneously use a network. The improvement in technology in

[10] GSM was originally an acronym for 'Groupe SpécialMobile' but this was later changed to 'Global System for Mobile Communications'

this period was mirrored in other developed countries and enabled the post-1995 mass diffusion of mobile telecommunications.

The rapid technological progress in the wireless transmission of calls, messages, and mobile internet since these early standardisation exercises has led to increased reliability and quality such that consumers in advanced economies are willing and able to substitute away from traditional fixed-line telecoms in favour of their mobile phone. Indeed, the fixed line telephone which had dominated long distance communication since the second world war was soon overshadowed as the global number of mobile telephone subscriptions exceeded fixed line for the first time in 2002 as indicated in figure 2.1. The same graph further indicates the the absolute number of global fixed-line connections begins to fall after 2007, indicating that mobile phones usage is not only increasing relative to fixed-line, but that it is also replacing the older technology.

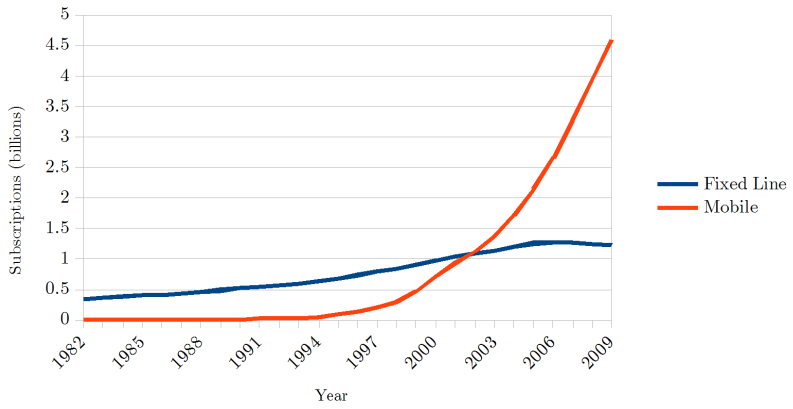

Figure 2.1.: Fixed line[1] versus mobile[2] telephone subscriptions 1982-2009

Source: [1]ITU 2010, [2]WCIS 2010

It is not only in the developed world that mobile telephones have become popular. Where the high cost of infrastructure combined with relatively low levels of wealth and income had stifled the expansion of fixed line communications in expansive developing countries, the comparatively low cost of building a mobile network led to rapid adoption in developing countries and the 'leapfrogging' of traditional technology [Waverman et al., 2005; The Economist, 2009]. Figure 2.2 indicates that lower middle-income countries began adopting mobile telecoms at around 2000 and, moreover, that adoption in

lower income countries was accelerating by 2009.

Complementing the improvement in broadcasting technology was an improvement in telephone handsets in the late 1990s as traditional manufacturers of communications and broadcasting equipment increasingly diverted resources toward creating products which would appeal to consumers. Early leaders in this market were those firms which had been active in developing the technological standards by which mobile networks could operate. They were able to leverage this advantage into the production of mobile telephone handsets which were increasingly portable and which adopted consumer-centric design features - many of which became common across different manufacturers' handsets [Koski and Kretschmer, 2007].

Since the 1990s the co-evolution of technology in mobile telecommunications has continued as improvements in speed and reliability of services are introduced by mobile networks, while handset manufacturers continue to include support for these innovations in their handsets; thus driving demand for these improved network services in a virtuous circle of product innovation. The continuing appetite for cell broadcast mobile telecommunications, and the evolution of technology to adapt to offer an increasing array of services, means that new markets continue to be exploited - both in terms of new adoption in developing countries, and also new market segments to be exploited

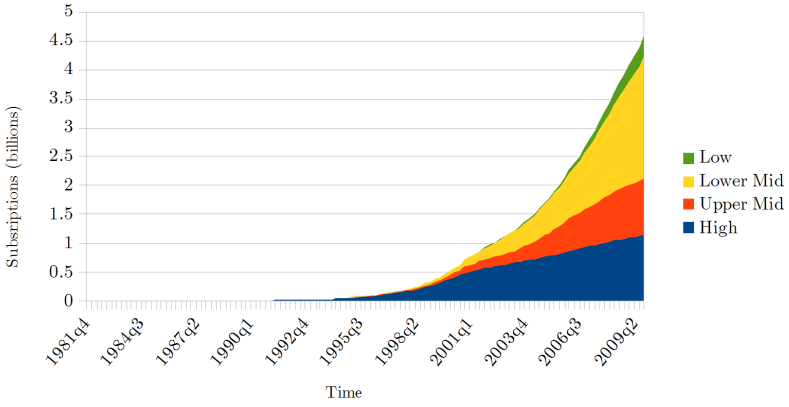

Figure 2.2.: Global mobile subscriptions by World Bank country income categories 1981-2009

Source: WCIS 2010

in the developed world.

The following sections offer a stylised view of the structure of the consumer-focussed mobile telephony industry with the emphasis placed on the main parties of interest in the case of the iPhone; handset manufacturers and mobile network operators. A subsequent analysis of the the market structure of both networks and manufacturers follows, with specific appreciation of the mode of competition. Finally the section concludes with a detailed analysis of the patterns of exclusivity of the iPhone which motivate the paper.

2.2. Technology and Competing Standards

The operation of a mobile telephone network requires that all equipment associated with it, both at a consumer level and also that engaged in the centralised broadcast of signals, conforms to a single technological specification; otherwise known as a technological standard. This standard determines the mode by which signals are broadcast, the type and frequency of the signal, and the technology of the handset which must send and receive the signal.

According to David and Steinmueler [1994] the purpose of a common standard can be subdivided into three possible functions; a standard for reference to ensure a product is of a specific design, a minimum quality standard (which ensures a product is of a certain quality), and compatibility standards which ensure interoperability. Telecoms standards fit into the first category and the latter; the name of the technology is a reference signal that allows a consumer to determine whether a handset will be compatible with the network - enabling confident purchases where a consumer might have multiple options, and also (from a production perspective) ensures the device complies to a list of technical list of specifications to ensure interoperability with other devices.

Although, in GSM, Europe adopted a single technological standard for mobile telecommunications there are alternatives - some of which have become obsolete, and some of which are technologically equivalent and currently used in non-European countries. The main alternative to GSM is known as CDMA[11]. CDMA and GSM were developed in a similar time period and are functionally almost identical; they primarily differ in

[11] An acronym for 'Code Division Multiple Access'.

the specifics of how they break down and broadcast mobile signals - this makes them natively incompatible. Because this lack of compatibility is common between different technological standards technical solutions are often established to remedy this. Indeed, in some countries (notably the US) where there are multiple competing standards, Church et al. [2008] highlight a fourth function of a standard - allowing the design and use of technologies enabling interconnectivity between different standards.

Both Funk [2009] and Selian [2000], the latter with a GSM focus, offer papers charting the development of these current commercial systems and specifically the pre-consolidation stage where many countries operated their own proprietary mobile phone standard. From these disparate national systems both Garrard [1997] and Funk and Methe [2001] chart the rise of the uniform standards; particularly contrasting the use of committees to design and implement a single standard such as in Europe, versus the US where the choice of standards was commercially led.

Support for mandated standardisation is mixed; both Grüber and Verboven [2001] and Li and Lyons [2012] suggest in their empirical analyses that having a common mobile technology increased the speed of diffusion relative to the case with competing standards.[12] Haug [2002] offers anecdotal evidence of the benefits stemming from the large-scale adoption of the single GSM standard; noting that the economies of scale involved in the production of equipment for the standard led to lowered final handset prices. These lower prices led to increased adoption outside of the original geographic base of the standard - particularly in poorer countries - this effect is evident in figure 2.2. David and Steinmueler [1994] alternatively report uncertain results based upon whether a common standard is internalized by small groups of firms or by the whole market; the former case may result in unintended anti-competitive effects if the market power of the incumbent firms is too strong.[13] Church et al. [2008] also suggest that standard setting organisations can be remote from the market - resulting in standards which are less well suited to market demand relative to those products of a competitive process.

Finally, standards may lead to network effects or switching costs for subscribers; these are discussed further in section 2.6.

[12] Grüber and Verboven [2001] also find that it was the implementation of GSM technology that allowed many more simultaneous users which enabled the introduction of multiple competing network operators, which in turn proved to be the engine behind the mass adoption of mobile technology.

[13] This is relevant in analysis of the early handset market shares in section 2.4

2.3. Vertical Industry Structure

The use of mobile telecommunications depends upon two components; a handset with which to make and receive calls (or perform the broader functions of a mobile phone), and a network which will broadcast the signals which enables users to be connected to each other or connected to content such as the internet. These requirements broadly determine the industry structure as being comprised of two separate components; handset manufacturers and network operators (referred to as operators) - these are indicated in figure 2.3.

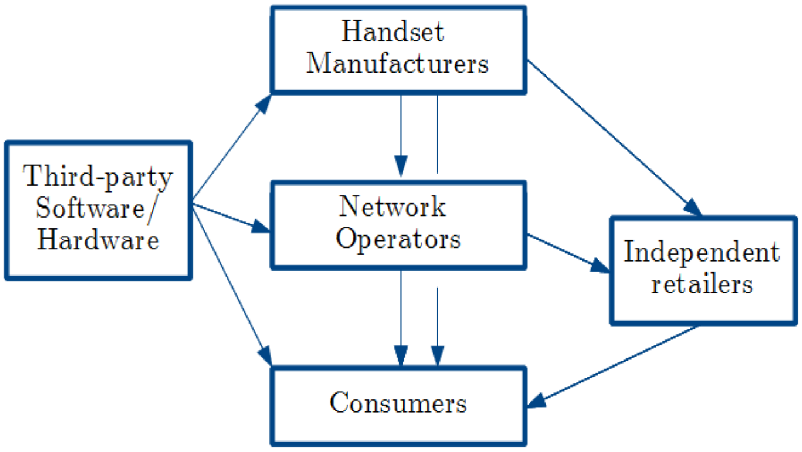

Figure 2.3.: Vertical structure (arrows indicate direction of goods)

The interpretation of the vertical industry structure is influenced not only by the interactions of firms with final consumers, but also by the interactions between the manufacturers and operators. Because of the above requirements, a consumer must acquire a handset and enter into a relationship with a network operator - where, much like in many other communication services, the subscription to a mobile network is not normally a one-shot purchase but instead entails a longer term subscription with the operator meaning that individuals keep the same phone number.

In order to acquire a mobile handset an individual consumer has several options; they may purchase one directly from the manufacturer through its own sales channel, pur-

chase one from a retailer, or purchase one through a network operator. Alternatively, a subscription to a network can be entered into through the operator themselves, or otherwise through an independent retailer.

Network subscriptions are generally one of two types; they can be either be of a fixed term with a monthly subscription fee which typically includes a built-in allowance in terms of number of minutes, data use, or text messages (this is known as post-pay since any usage in addition to that included is paid for after the event), otherwise subscribers enter into pre-pay agreements where users add credit to their account up front and usage is billed to this credit at a pre-agreed rate. When not contracted directly with the network operator pre-pay subscriptions are routinely sold in a range of different retailers, often over the counter in supermarkets, but fixed-term agreements tend to be sold by specialist retailers acting as agents for the mobile network.

While the direct purchase of a handset from a manufacturer is typically a one-shot agreement, the purchase through a network typically involves the purchase of a bundle of phone and network subscription featuring a subsidy on the price of the handset. This is either as part of a bundle with a fixed-term post-pay subscription agreement where an individual may pay only a small amount or even nothing upfront for the phone, or otherwise where there is a small discount to the retail price and the phone is restricted for use only with the network in question; this latter subsidy is generally associated with pre-pay agreements not subject to a fixed term and where future revenue streams are less certain. Purchases of handsets through retailers may be either without restriction or subsidy (a standalone product which can be used ith an existing mobile subscription, or otherwise may involve sale of a phone-subscritpion bundle.

That the bundling of products is unidirectional (handsets bundled with contracts, but not vice versa) influences the interpretation of handset manufacturers being upstream of network operators and providing an input into the business of the operators. This assumption on the structure of the market informs the subsequent analysis.

2.4. Competition between Handset Manufacturers

Mobile handsets are durable goods, necessary in order to access a mobile network, and are characterised by a high rate of product innovation. Owing to this innovation it is

customary that users of mobile phones tend to replace their handset periodically; this is closely linked to the fixed term nature of subscriptions to mobile networks and the subsidy of handsets for new subscribers.

The manufacture of mobile telephone handsets is an industry dominated by a small number of firms, most of which are large electronics manufacturers with interests in a range of fields such as televisions, computers, or communications infrastructure. Although there are regional variations, the same handset manufacturers compete against each other in almost all countries. The largest market participants in handeset manufacturing are also persistent over time as indicated in figure 2.4[14] which indicates that Nokia, Samsung, and LG have consistently been amongst the largest manufacturers in terms of handset sale volumes.

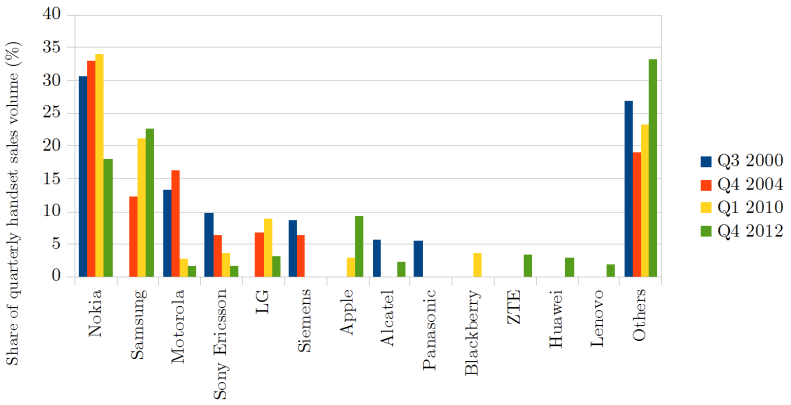

Figure 2.4.: Share of quarterly global handset sales by volume (Q3 2000[1], Q4 2004[2], Q1 2010[3], Q4 2012[4])

Source: [1]BBC News, [2]cellular-news, [3]E-week Europe, [4]Gartner

The firms that manufacture mobile handsets compete in a number of ways including price, patenting activity, handset proliferation, and through the creation of horizontally differentiated ecosystems such as application stores; this latter area is discussed in the relation to network effects and switching in section 2.6.

[14]In figure 2.4 Sony-Ericsson was known as Ericsson prior to a joint venture in 2001, and is now Sony, following the Sony purchase of Ericsson's stake in 2011. Furthermore, where a manufacturer is shown as having a 0% market share it may have had a very small market share and be included within the 'Others' category.

There are a number of papers which have studied pricing of mobile handsets; Barros [2006] does so from the perspective of final prices to consumers and the use of subsidies by mobile operators to incentivise consumers to lock themselves into fixed term contracts - this is discussed further with respect to the strategies of operators in section 2.5. More relevant evidence from the perspective of manufacturers is provided by Costello [2010] and Valletti [2000] who respectively indicate that manufacturers are making slim or negative profits in their handset divisions, and that there is evidence that prices are declining at both wholesale and retail level.

The high speed of innovation and technological advancement in mobile telecoms (which was discussed in relation to the competing standards in section 2.2) presents the opportunity for firms to engage in patenting; both in terms of essential patents - those required for the operation of a mobile network, and also patenting of features on handsets which appeal to consumers.

The number of high profile patent cases involving manufacturers of mobile telephone handsets, typified by Apple Inc. v. Samsung Electronics Co. Ltd. et al. at the Northern District Court of California (C 11-1846 and C 12-0630), is an indication of the investment that firms have made in using patenting in order to gain a competitive advantage over rivals. In a number of cases this has resulted in a ban on sales of particular handsets or equipment in particular territories following a finding that a patent has been violated. The importance of patents in gaining competitive advantages is also manifested in the investment decisions of firms with patent stockpiling being credited for a number of high-profile horizontal mergers.[15]

There is evidence that the patenting activities of firms has been a determinant of the historical market shares held by different firms. Both Bekkers et al. [2002] and Koski and Kretschmer [2007] highlight the parallels between the early market shares of Nokia, Ericsson and Siemens, and the firms' investment in patenting activities surrounding the GSM standard; this is particularly relevant for pre-1997 'essential' patents - those that are mandatory for the operation of handset. To this effect Koski and Kretschmer [2007] also highlight that the advance in technology from 2G GSM to 3G created a watershed moment where new technological opportunities presented the opportunity for new

[15] Notably the acquisition of Motorola by Google, and also the full merger of Sony and Ericsson's mobile divisions in 2012.

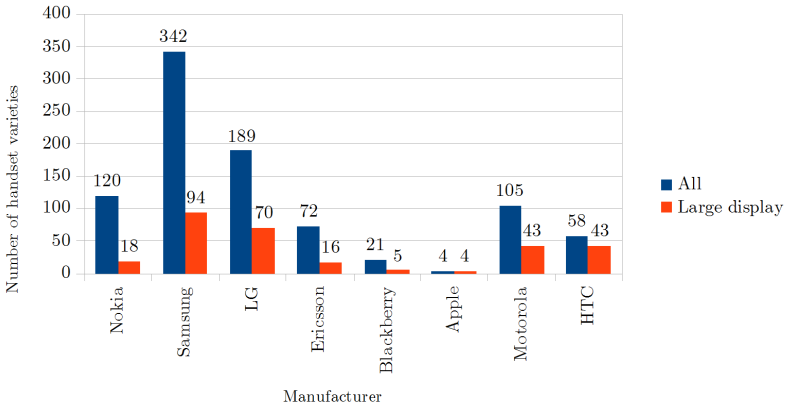

Figure 2.5.: Handet varieties by leading manufacturers January 2007 - February 2011)

Source: GSM Arena (February 2011)

innovative entrants to gain a foothold in the market; highlighted in figure 2.4 by the aggressive entry of Samsung and LG between 2000 and 2004, and the decline of many of those firms which had previously held significant market shares.

In addition to patenting activities which protect innovation, mobile handset manufacturers also engage in product proliferation - producing large numbers of handsets with minimal differentiation; Schmalensee [1978] states that, in producing large numbers of varieties, incumbents can stifle entry by making it difficult for potential rivals to reach a minimum efficient scale. This type of behaviour is shown in figure 2.5 which shows the large numbers of individual handsets which were marketed by the manufacturers.

Further to the above, Koski and Kretschmer [2007] discuss the emergence of dominant designs which are introduced by a single firm, become imitated, and finally become the norm for phone designs; specifically, the authors state that since the late-1990s manufacturers sought to differentiate themselves not just through size and weight, but increasingly through innovation in features. The authors also state that these features which were innovative in the 1990s (such as alarm clock or games) became standardised across handsets by 2002.

Until 2007 mobile telephone handsets had maintained a broadly uniform design featuring a small screen and a physical keypad with buttons which had to be pressed in

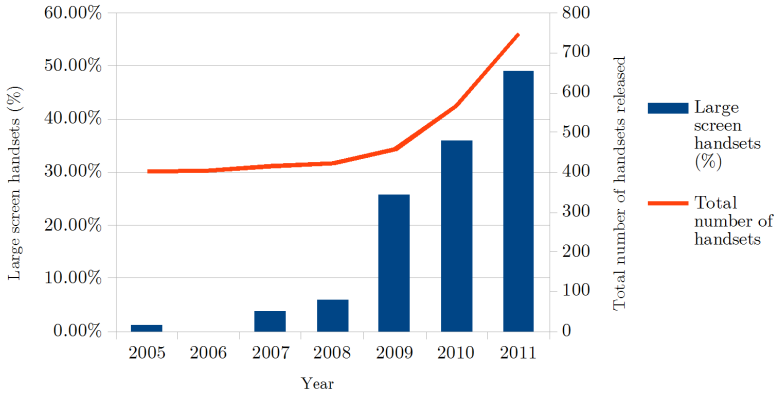

Figure 2.6.: Proportion of handsets featuring large screens (%)

Source: GSM Arena (June 2013)

order to operate the phone. Toward the end of this period manufacturers began to include large screens on their phones which replaced buttons; this style of handset soon overtook the previous approach. Figure 2.6 indicates that, while the total number of handsets released annually increased over the period 2005 to 2011, the proportion of these featuring a larger screen (greater than three inches diagonally) also increased[16]

The significance of figure 2.6 is two-fold; it highlights the incentives for patenting through the potential for the extraction of royalties in mobile handset design, and it indicates that advantages gained through innovation can be transient and that substitute products will rapidly adopt innovations.

2.5. Competition between Network Operators

Mobile telephone networks are operated on a national basis where each national market has a small number (typically less than five) operators which compete to attract subscribers to their service. While the manufacturers of handsets are often active in other complementary markets, network operators are often active in the provision of other communication services such as broadband or fixed line telephone services. Although

[16]The criteria for selection of handsets in figures 2.5 and 2.6 was that they had a screen with a diagonal distance in excess of three inches; consequently these may also include some non-touchscreen devices which had unusually large screens.

operators compete at a national level in each territory, the industry is dominated by multinational firms which operate networks in a number of countries.

Because mobile telephone signals are broadcast using frequencies, much like a conventional FM radio, any firm that wishes to operate a mobile network must, like a radio station, operate on its own frequency. This ensures that, like radio stations, each network can broadcast their services without interference from the signals of rival networks. These technical considerations mean that the operation of mobile networks must be tightly regulated because the usable bandwidth (the total number of possible frequencies) is finite and must be rationed.

As a result of this rationing, the entry of mobile network operators into a given market is through the allocation of licences which allow an operator to broadcast over a specific set of frequencies. In general the number of licences which are issued in a country has been determined by the technology available; the introduction of GSM and CDMA technologies permitted many more users to simultaneously use the available frequency bandwidth, which enabled greater numbers of firms.[17]

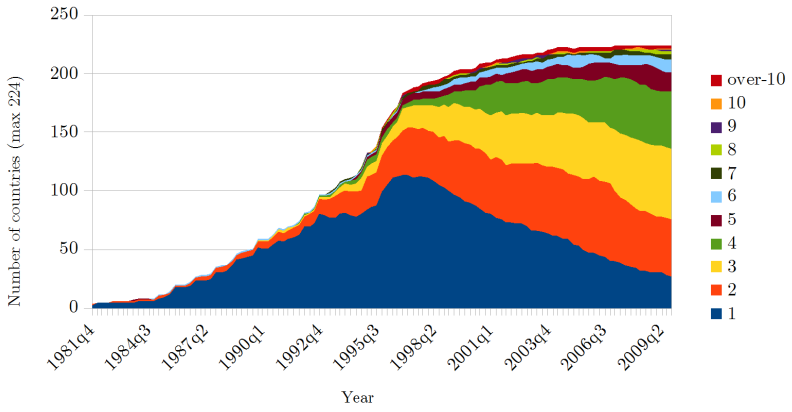

Figure 2.7.: Cumulative distribution of operator numbers 1984-2009

Source: WCIS 2010

Figure 2.7 shows the total number of countries with mobile telecommunication net-

[17]The UK initially had a national duopoly but this was increased to four firms following the introduction of digital networks in 1993.

works broken down by the number of network operators within the country. The graph indicates that in most countries the general trend was for a single monopoly network operator until the mid-1990s. This is confirmed by Grüber and Verboven [2001] who indicate that, of 118 countries which adopted an early analogue standard (pre-GSM or CDMA), 88 initially licensed a single monopoly operator. Of the later-adopting countries which skipped the analogue technology and implemented a digital GSM or CDMA network, 48 out of 87 issued multiple licences to competing providers.

The way in which licences are issued has varied between countries such that in smaller countries (such as the UK) licences are nationally issued subject to an auction or otherwise through some alternative selection process[18]. In larger countries regulators have historically implemented licensing at a regional level, though these licensing arrangements have frequently led to a subsequent consolidation of separate regions; this was the case in Russia and the US - Parker and Röller [1997] explain that the US actually had 305 non-overlapping markets where each had two operators with one licence in each territory being determined by lottery[19], though India still has strict regionalisation.

Competition between mobile network operators is credited with increasing the diffusion of mobile telecoms [Li and Lyons, 2012; Grüber and Verboven, 2001] and mobile network operators are observed to compete to attract subscribers in a number of ways including price competition, vertical and horizontal product differentiation including the use of exclusive handsets and handset subsidies, or the bundling of mobile telecommunications with other complementary communication services. Valletti and Cave [1998] offers a detailed analysis, with evidence, for different manifestations of competition in UK telecommunications. Several broad themes in network competition are introduced below.

Network operators compete in price along a number of different dimensions including differences in upfront unit costs for a minute of call, and different bundles of minutes, text messages and data. Valletti and Cave [1998] observe that early variety in tariffs (the monthly subscription price) was aimed at market segmentation between business users and consumers, but more recent evidence has highlighted the difficulties in comparing equivalent tariffs owing to the complexity and number of variables that must be taken

[18] Binmore and Klemperer [2002] offer an overview of the UK's licensing procedures from early 'beauty contests' to the 3G auctions in the year 2000.

[19] In reality a period of consolidation and acquisition meant that cellular operators were active in an average of 19 separate markets.

into account [Hatton, 2005]. There is further complexity in comparing equivalent costs of pre-pay and post-pay tariff where even pre-pay tariffs may feature non-linear pricing.

Network operators compete to differentiate themselves both vertically and horizontally. Where a network seeks to differentiate itself vertically this can either be through better coverage than its rivals (which would result in a greater number of people able to access the network, and also reduced likelihood that a user will be unable to use the network whilst travelling), or otherwise through improved technology such as faster data speeds. Horizontal differentiation can be in the form of additional non-telecom perks for subscribers such as discounted concert tickets[20], or discounted access to music subscriptions. Handset subsidies or exclusivity are also ways networks differentiate themselves and are designed to attract new users to a network, offset the inconvenience and lock-in associated with minimum term contracts, or incentive use of particular services; Barros [2006] finds that subsidies decrease with the increased market share of the network operator, and that they are increasing when the network operator is trying to introduce new services.[21]

The bundling of mobile telecommunications with other communication services such as broadband is a common mode of competition which is dealt with extensively in the second half of the present thesis (page 87 onward). Frequently these bundles are sold at a discount to the separate selling prices which makes them attractive to consumers, but they are also associated with a decreased willingness to switch provider[22]; meaning that they serve both the purposes of customer acquisition and retention. The results in section 6.3 (page 151) further confirm the impact of bundling products in reducing switching of provider.

Although clearly a vertically-linked industry, instances of vertical integration between handset manufacturers and network operators are rare; though there are a number of instances where a network operator will offer a private-label mobile phone.

[20] These types of offers are often associated with credit card companies or non-monetary benefits associated with certain bank accounts.

[21] Barros [2006] uses the example of the introduction of 3G technology (an improved digital standard) and the subsidy of phone handsets which could use this technology.

[22] Ofcom [2008] features a consumer survey using focus groups in which consumers stated an unwillingness to unbundle communication services once they subscribed to bundled products.

2.6. Switching costs and network effects

Both handsets and mobile networks are characterised by the presence of network effects and switching costs. Both these phenomena are addressed more fully in the second part of the thesis but they are briefly outlined below with specific reference to mobile telecommunications.

Network effects mean that the value of the product to an individual is not just in their own consumption, but also in the consumption by others; this can be true of subscribing to a mobile network, or using a particular brand of handset. Switching costs alternatively make it costly to switch from consumption of one brand to another; they are particularly prevalent where consumption is characterised repeated purchases or by long-term relationships such as subscriptions, or durable goods.

Network effects can be characterised as being either direct or indirect; a direct network effect is a direct benefit that stems from the number of users – an example is the adoption of telephones where the benefit an individual subscriber receives is not only related to their own adoption, but also to the adoption by others whom they can call. Direct network effects are particularly present in the early stages of adoption of technologies and are frequently associated with introductory offers designed to boost early adoption.[23] Indirect network effects are created by where adoption or use of one product leads to an increase in the quality of an associated product; well-known examples include the case of video game consoles where the benefit from increased adoption is that more companies are attracted to produce games.

Network effects arising from the choice of mobile network operator are primarily direct, though there are some issues and types of horizontal differentiation which give rise to indirect network effects.

Direct network effects stem from the adoption of mobile telecommunications in general since, like all forms of communication, the adoption by others benefits all subscribers. More specifically, network effects arise from the choice of standard (as per section 2.2), and the choice of mobile network.

[23] This is often the case where the adoption of technology has some 'tipping point' where a certain rate of adoption must be reached, and without which a technology or product will fail.

The implementation of a single GSM standard in Europe was intended to maximise the benefit to individuals of a single technology for mobile telecommunication - cross-border compatibility meant that users benefited from the geographical scope of GSM services [Haug, 2002]. Where there are multiple competing standards in mobile telecommunications this does not necessarily guarantee that users of one standard benefits from overall adoption of the service; this is dependent upon the interoperability of the technologies.

Within a single standard, there may be network effects in relation to the mobile network operator to which individual subscribes. The primary source of these network effects stems from price differences associated with calls between subscribers to the same network operator (known as 'on network calls'), and calls between subscribers to different networks; these extra costs stem from interconnection charges which are charged by either the receiving network or the calling network depending upon the regulatory environment[24]. In Europe the interconnection charge is paid by the individual making the call (as opposed to the US where individuals may have to pay to receive a call) and is known as a termination rate - the rate charged to the calling network by the receiving one in order to terminate the call. Figure 2.8 indicates that these termination rates have declined over time on average,[25] but that there still existed disparities between different countries.

Where it costs a subscriber more to call between mobile networks this creates local network effects where, rather than the total subscriber base, the benefits of being a subscriber to a mobile network stem from co-ordination with individuals that an individual is likely to call, rather than the total number. To this effect both Birke and Swann [2005] and Corrocher and Zirulia [2009] investigate the extend to which an individual's choice of mobile network operator linked to that of their peers; both find that the network choices of peers affect an individual's choices.

There are limited indirect network effects relating to an individual's choice of network provider though, where networks engage in horizontal differentiation such as subscriber special offers, network size is likely to lead to improved range or quality of these benefits.

[24]This depends upon whether there is a regime of calling party pays (CPP) or receiving party pays (RPP); there has been some investigation into wider effects of these payment regimes - notably Littlechild [2006].

[25]The data includes a sample of 31 European countries.

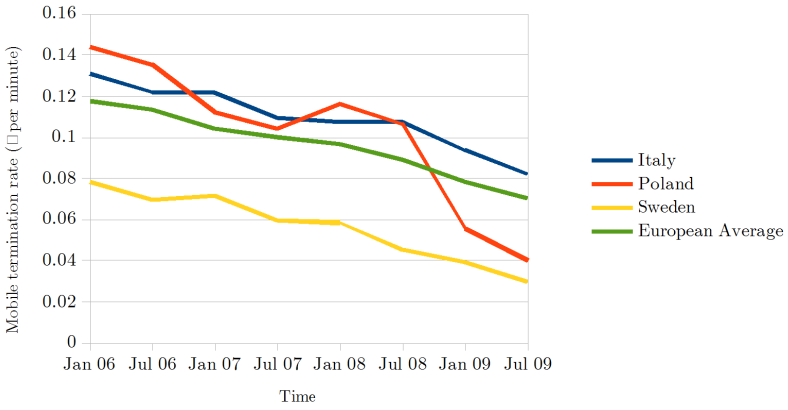

Figure 2.8.: European termination rates 2006-2009

Source: European Regulators Group

The network effects associated with an individual's choice of handset are dominated by indirect effects, though there are some simple local network effect associated with the likelihood that a peer has a particular peripheral or charging plug for the phone. The introduction of phone operating ecosystems, much like standard computer operating systems, means that third-party software developers can be attracted by the number of users of a particular phone - leading to greater publishing of applications; this is an example of the logic frequently applied to video game consoles. Church et al. [2008], in their theoretical investigation, illustrate that there exist positive adoption externalities from indirect network effects under plausible conditions that there are economies of scale in production of software, entry to the associated market is free, and that consumers value variety; they use the example of a computer and associated third-party software.

Where network effects are an incentive for an individual to adopt a particular handset or mobile network, they can equally create a cost for individuals seeking to switch away from a network or handset. Foregone beneficial network effects are not the only source of switching costs; Xavier and Ypsilanti [2008], Valletti and Cave [1998], and Baker [2007] state that individuals wishing to switch their subscription from one mobile operator to another may face financial early exit charges (if still within the minimum contract period), administrative burdens in transferring numbers, pricing obfuscation which increases search costs, or technical incompatibility between equipment which may

result in a financial cost. These switching costs arising from incompatibility of equipment arise from to sources; where a handset is fixed to a particular mobile network, and where, in the case of competing standards, a handset is specific to a particular technology [Grüber and Verboven, 2001]. The costs associated with new handset purchases are often ameliorated by the mobile networks which bundle handsets with minimum-term subscriptions to the network - often with substantial subsidies; this is regarded as one of the key competitive strategies for mobile operators [Valletti and Cave, 1998; Valletti, 2000; Barros, 2006].

2.7. Summary

The previous sections show that the scope of mobile telecommunications is global and that both mobile network operators and handset manufacturers compete in a number of ways. These observations inform the variables that are included in the later analysis. The chapter has also provided a technical background to help the reader understand the concepts and terminologies which are central to the investigation.

3. Analysis of Entry and Exclusivity

The current investigation explores the determinants of the distribution pattern pursued by a single upstream manufacturer, Apple, in the context of intra-brand competition. The literature and characteristics of the market show that there are a number factors which must be taken into account including the market structure, demand, and the type and level of technology in each country. The following sections outline the theory behind the econometric approach, the data, and finally the model specifications and results.

3.1. Econometric Methodology

The supply decision of Apple, the manufacturer can be simplified as a multi-stage decision process. Specifically, the decision to enter a market; the decision to supply exclusively; and, in the case that exclusive distribution is chosen, the decision over the duration of such exclusivity. The decision over the duration over which to extend an exclusivity agreement is necessarily subject to the decision to supply exclusively.

The decision process is depicted in figure 3.1, below, where the term π_{in} is an expression for the likely profit Apple would achieve by entering the market.

In the simple analysis it is assumed that at each decision point the manufacturer chooses the option which provides the greatest surplus subject to two constraints: it earns non-negative profits; and the network retailer(s) to which it makes an offer to must make at least as much profit as its outside option provides. The downstream constraint is intuitive since the iPhone is one of a number of phones the operator can sell, the operator may make greater profit by selling alternative models. Both these conditions are logical; firms will not enter an agreement which leaves them worse off, and Apple has the outside option of not entering the market (assumed to deliver zero profits).

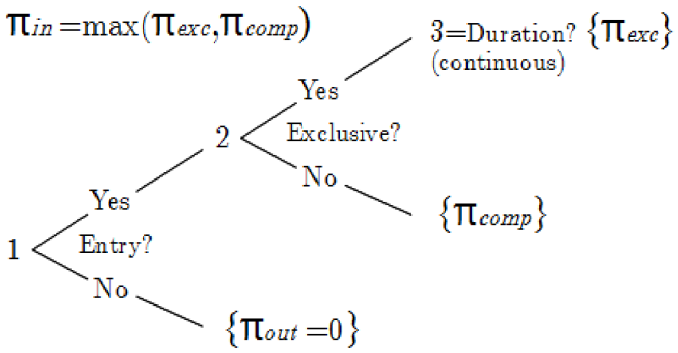

Figure 3.1.: Apple's market entry decision

The decision over whether to deal exclusively is driven by the factors which were identified in the prevailing literature such as adverse selection on the part of downstream firms, or market imperfections and uncertainty. Exclusive distribution agreements may, alternatively, be necessary in order to incentivise the participation of downstream firms (or, more accurately, *a* downstream firm). Linked to Lafontaine and Slade [2005] is the notion that a certain market size must be guaranteed to a single downstream firm in order for them to participate; notably in the presence of downstream fixed costs. In this case one might expect a small, or particularly undeveloped, market to be unable to support two competing downstream firms, in which case the downstream non-zero profit participation constraint would not be satisfied for two downstream firms.

There is, however, little in the background material to inform a-priori expectations concerning the durability of exclusivity agreements. In this respect Boyd [1993] is relevant as the author highlights that the optimal vertical restraint imposed on a downstream firm may vary over time according to the product cycle.

The entry decision is determined by the revenue from entry, either by exclusive or competitive means, and the costs that Apple is likely to face in selling into a market. Costs of entry might include transportation of the product, expenses to protect intellectual property, or fixed costs associated with adapting a device for a particular territory.

In order to more formally understand the decisions in figure 3.1 the decisions are split into two distinct stages (this is reproduced in figure 3.2). For any country or territory if at stage B $\pi_{in} = \max(\pi_{exc}, \pi_{comp}) > 0$ then at stage A the decision is taken to enter the market. Given that entry has occurred the most profitable strategy is pursued subject to the outside-option profit constraint for the downstream firms(s).

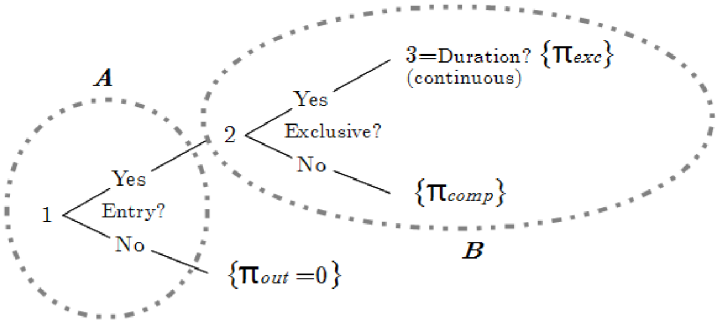

Figure 3.2.: Apple's market entry decision

The analysis is performed in two stages, the entry choice of the upstream manufacturer at A, and the exclusivity decision at B. The two stages are modelled independently,which means they are estimated separately with the investigation at stage B executed against the subsample of countries where the iPhone was sold.

The observer will not that the decision nodes at stages 2 and 3 are estimated using a single process. This is necessary as a result of distributional issues surrounding the analysis of censored data. This is discussed at length in section 3.1.2.

For each country (i) the profitability which drives decisions in A and B is some function of the characteristics of the country (demographics), the market and competition, and the technological profile of the country. Following from the assumption of independence of the stages earlier there is no restriction that, for instance, the demographic determinant of entry is identical to demographic determinants of exclusivity. This unstructured approach abstracts from particular profit functions for either upstream or

the downstream firms.

$$\begin{aligned}
\text{Entry}_i &= f\left(\text{demographics}_{1,i}, \text{market}_{1,i}, \text{technology}_{1,i}\right) \\
\text{Exclusivity}_i &= f\left(\text{demographics}_{2,i}, \text{market}_{2,i}, \text{technology}_{2,i}\right) \\
\text{Duration}|\text{Exclusivity}_i &= f\left(\text{demographics}_{3,i}, \text{market}_{3,i}, \text{technology}_{3,i}\right)
\end{aligned}$$

The following sections outline the models used to estimate the likelihood of Apple's selling into a country, and the excusivity decisions of the manufacturer.

3.1.1. Entry Decision

The propensity of Apple to sell phones into a specific market is likely to be some function of both the characteristics of the country and the market:

$$\begin{aligned}
\text{Entry propensity} = I\,(&\text{Country size, Country population, Country income, Country region,} \\
&\text{Market competitiveness, Number of firms, Market technology}) \qquad (3.1)
\end{aligned}$$

While the above factors influence the entry decision it is not possible to observe the true entry function on which the propensity to enter the market is based. Instead we observe, based upon the characteristics of the country, whether (or not) the iPhone was *actually* launched. In this respect the observed entry decision is a binary yes/no based upon some underlying latent profit function.

Binary Choice

In order to formally analyse the launch of the iPhone a Probit model is employed based upon the random utility framework of Greene [2012].

In each country 'i', where there are $j = 1, 2, ..., N$ operators. The maximum potential profit which can be extracted by Apple by contracting with '$n \leq N$' network operators is indicated by the expression '$\max \sum_{j=1}^{n} \pi_{i,j}$'. At this point it is not necessary to define the exact number n, only to understand that in each country there exists some optimal level of $n \geq 0$ which delivers the highest level of profit. The determination of n is the subject of the second half of the investigation.

Defining $\Pi_{i,out}$ as the profit for Apple if it chooses not to sell into a country, and $\Pi_{i,in}$ as the profit gained upon entry:

$$\Pi_{i,out} = 0 \tag{3.2}$$

$$\Pi_{i,in} \max \sum_{j=1}^{n} \pi_{i,j} = \mathbf{x}_i'\alpha + \varepsilon_i \tag{3.3}$$

From equation (3.2), Apple's profit from non-entry is equal to zero. Equation (3.3) indicates that the profit from entry into i is dependent upon a vector of characteristics ($\mathbf{x}_i$). These characteristics are associated with a fixed set of coefficients (α) and an error term which accounts for unobserved heterogeneity between countries - ε_i.

Since Apple will enter a market if it makes non-negative profit, the probability of such entry can be expressed:

$$\begin{aligned} \text{Prob}[Entry_i = 1|\mathbf{x}_i] &= \text{Prob}[\Pi_{i,in} > 0] \\ &= \text{Prob}[(\mathbf{x}_i'\alpha + \varepsilon_i) > 0|\mathbf{x}_i] \end{aligned} \tag{3.4}$$

Probit Estimation

Apple is basing their entry decision based upon unobserved and unknown upstream and downstream profit functions, hence the true profitability cannot be observed. The

actual decision to enter *is* observed and can be expressed as a binary variable (1=enter, 0= no). From (3.4), which is based upon the underlying profit function, it is possible to use a relevant set of observed variables to estimate the decision by Apple to enter market i as some latent variable E_i:

$$E_i \quad = \quad \mathbf{x}_i'\alpha + \varepsilon_i$$

Thus, much like the net utility calculation of (3.4) the decision to switch is implicitly illustrated by the condition:

$$\text{Enter}_i = \left\{ \begin{array}{l} 1 \text{ if } E_i \geq 0 \\ 0 \text{ if } E_i < 0 \end{array} \right\} \tag{3.5}$$

Thus, from (3.5) and (3.5) the probability that Apple enters a country is:

$$\text{Prob}[E_i \geq 0] \quad = \quad \text{Prob}[\varepsilon_i > -\mathbf{x}_i'\alpha] \tag{3.6}$$

By assuming the error term ε_i to be normally distributed according to $\varepsilon_i \sim N[0,1]$, which is symmetrical, the above can be rewritten:

$$\text{Prob}[E_i \geq 0] \quad = \quad \text{Prob}[\mathbf{x}_i'\alpha > \varepsilon_i] \tag{3.7}$$

In imposing the standard normal distribution on the error term the Probit model is being used, as such, the standard normal distribution function is used in calculating the probability of entry ($E_i > 0$):

$$\text{Prob}[Enter_i = 1] \quad = \quad \int_{-\infty}^{\mathbf{x}_i'\alpha} \phi(E_i) dE_i = \Phi(\mathbf{x}_i'\alpha) \tag{3.8}$$

Where ϕ is the standard normal distribution and Φ the cumulative density function for the standard normal distribution; where $\Phi(E_i > 0) > 0.5$, creating a positive probability of entering. The Probit model is calculated using maximum likelihood estimation.

3.1.2. Exclusivity and Duration

The current study empirically examines the duration of exclusive distribution agreements made by Apple in the initial years of the availability of the iPhone. This analysis of exclusivity presents a challenge to the econometrician. Because there are a large number of countries in the sample in which exclusivity was not pursued this means that any variable examining the duration of exclusivity across the sample will contain many zeros. Although the presence of zeros in a dataset per se does not itself create difficulties, the issue in this instance is that the zero values represent a censoring of the dataset. They constitute an artificial minimum value imposed on the duration variable.

Censoring or Limiting of Datasets

Data is considered to be censored or limited when an otherwise continuous variable has a probability mass at one or more points [Wooldridge, 2002]. To illustrate the effect of a censored or truncated variable figure 3.3 shows two distributions for the variable $\mathbf{x}$. Distribution I is normally distributed, while II shown the same variable truncated at some value $\underline{\mathbf{x}}$

Distribution II shows a probability mass at the imposed lower bound $\underline{\mathbf{x}}$. This probability mass results in distortions to the mean of the variable and intuitively results in biased estimated coefficients when using the variable in analysis. When using a truncated dependent variable Tobin [1958] observes that the concentration of observations at the limiting value makes conventional OLS multiple regression inappropriate since this will violate a number of the regression assumptions concerning the distribution of error terms.

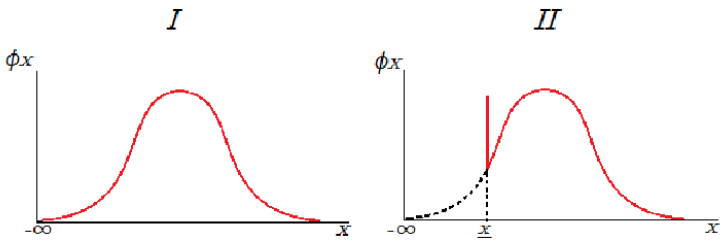

Figure 3.3.: Truncated variable **x**

Data which is commonly censored includes data on purchase and consumption decisions - or any variable where there is a positive probability of a zero result. In the case of consumption purchases negative values are unrealistic (a consumer rarely makes a negative purchase of, for example, tomatoes). The problem with analysing the continuous nature of this lower censored data is that there may exist a subset of observed zeros that, given the characteristics of the individual, would actually seek to make a negative purchase (they *really* dislike tomatoes).

There have been a number of solutions proposed to address the problems associated with the estimation of coefficients when analysing a censored continuous dependent variable. The models which have been proposed operate by splitting the estimation of the sample between those observations which are censored and those which are not.

The censored Tobit model [Tobin, 1958] addresses this issues of censorship. Like the Probit model explained in 3.1.1 it assumes that the censored variable which is observed (Duration) is actually related to some underlying latent variable, D, such that:

$$D = x\beta + u, \; u|x \sim \text{Normal}(0, \sigma^2)$$

$$\text{Duration} = \max(0, D)$$

In this instance the underlying latent variable is only observed subject to the passing of the zero threshold, but there is a positive probability mass at zero. The Tobit model

proposes the following likelihood function which, when maximised, yields estimates of the vector of coefficients, β::

$$f(\text{Duration}|x) = \underbrace{\{1 - \Phi(x\beta/\sigma)\}^{1(D=0)}}_{A} \underbrace{\left[(2\pi)^{-\frac{1}{2}}\sigma^{-1}\exp\left\{-(y-x\beta)^2/2\sigma^2\right\}\right]^{1(D>0)}}_{B} \quad (3.9)$$

In (3.9) the likelihood function has two components; the likelihood that $D = 0$ indicated by A, and the likelihood that $D > 0$ shown by B.

In the case of data which is censored at zero, the shortcoming of the Tobit model is that both the probability the $D > 0$, and the value of D for any value $D > 0$ are determined by the same mechanism and the same vector of parameters. This restriction is logical in an example where consumption of a good is solely some function of income and zero consumption of the good the result of financial constraint. However, in many cases the relationship between the two stages is not so clear.

Using again the example of consumption; suppose that desired consumption of the good is not only determined by income, but also determined by some parameter of personal taste unrelated to income (hair colour, for example). In this instance there would be a subset of individuals (possibly with brown hair) which would never choose to consume a positive quantity of the good, irrespective of their income. There is no link between passing the threshold and the final value of the variable.

In this case we are still interested in the value of the continuous variable. It is still necessary to control for the censored distribution of the continuous variable, but the binary variable which determines the passing of the threshold value is determined by some separate process.

3.1.3. Cragg's Tobit Alternative

Cragg [1971] proposes a two-stage or 'double-hurdle' alternative to the simple Tobit model in which the two stages (binary and continuous) can be determined by different processes.

In the relevant case of censoring at zero (as per the Duration variable), in order for the continuous variable to record a positive value two conditions must be met. The first condition dictates that the process determining the binary process must yield a positive response. The second condition rules that, subject to the first condition being met, the process determining the continuous variable is sufficient to deliver a positive outcome. Thus an observed value of zero may be the result of just *one* of these conditions not being met, while a positive value requires the satisfaction of *both* conditions. In the earlier simple case of consumption, the consumer would require a) the specific hair colour to indicate that they would be willing to consume the product, and also sufficient income to guarantee its purchase.

$$f(X, D|x_1, x_2) = \underbrace{\{1 - \Phi(x_1\gamma)\}^{1(X=0)}}_{A} \underbrace{\left[\Phi(x_1\gamma)(2\pi)^{-\frac{1}{2}}\sigma^{-1}\exp\left\{-(y - x_2\eta)^2/2\sigma^2\right\}\Phi(x_2\eta/\sigma)^{-1}\right]^{1(D>0)}}_{B} \quad (3.10)$$

In applying Cragg's model to the present case. The observed continuous duration variable is still denoted D, but a separately introduced binary variable is included, X, which is equal to 1 in the case that D is positive and zero otherwise. In this case X represents the presence of exclusivity.

The likelihood function for the Cragg [1971] double hurdle model indicated by equation (3.10), like the Tobit, has two components; the probability that $X = 0$ (A), and the likelihood that $D > 0$ given the censored continuous duration variable (indicated by the expression B). From (3.10) the maximum likelihood estimate of γ is the same as the Probit estimator discussed in section 3.1.1. Part B of (3.10) is readily identifiable as a probability-weighted truncated normal distribution. The term $\Phi(x_2\eta/\sigma)^{-1}$ ensures that the density of the truncated normal integrates to one.

Notable in Cragg's model is that the process determining the hurdle result and the positive value are different; they depend upon different vectors of variables (x_1, x_2), each with its corresponding vector of coefficients (γ, η). Where $x_1 = x_2$ the model permits the same dependent variables to act in different directions at different stages in the model if $\gamma \neq \frac{\eta}{\sigma}$. This allows for the separability of the determinants of the durability

of exclusivity agreements to differ from those variables determining the imposition of exclusivity.

Notably, the Tobit can be viewed as a special case of Cragg's model where $\gamma = \frac{\eta}{\sigma}$. This forms the basis of the Lin and Schmidt [1984] Lagrange multiplier test which tests this restriction to determine the appropriateness of the Tobit specification.

In summary, while the Tobit model remains a method for overcoming problems associated with a truncated distribution, Cragg's alternative is a true two-stage model which allows for the separability of the the impact of different variables at different stages in the model.

The following sections outline the data and specifications of the model which are to be tested under the different methodologies. The results are reported and discussed later in section 3.4.

3.2. Data

In order to make inferences on the determinants of entry, exclusivity, and the duration of exclusivity agreements this investigation uses a dataset gathered from a number of sources; it contains variables from off-the-shelf datasets and also data which has been collected. The data is summarised in table 3.1 while the correlation coefficients for the variables are shown in Appendix A. There are no instances where variables are perfectly correlated.

Table 3.1.: Variable summary

Variable	Source	n	Mean	Std. Dev	Min.	Max.
iPhone launched (1=yes)	Author's research	187	0.449	0.499	0	1
Exclusivity (1=yes)	Author's research	84	0.726	0.449	0	1
Duration (days)	Author's research	84	695.619	614.764	0	1836
Log Land Area	WB	187	11.265	2.692	3.332	16.611
Log Pop. Density	WB	187	4.23	1.535	-1.986	9.805
Log GDP/Capita	WB	187	8.441	1.568	5.222	11.839
Africa	Google	187	0.278	0.449	0	1
North America	Google	187	0.144	0.352	0	1
South America	Google	187	0.059	0.236	0	1
Asia	Google	187	0.225	0.418	0	1
Aus & Oceania	Google	187	0.059	0.236	0	1
Europe	Google	187	0.235	0.425	0	1
Num. Firms	WCIS	187	3.503	1.938	1	14
HHI	WCIS	187	0.477	0.198	0.169	1
Competing Standards	WCIS	187	0.118	0.323	0	1
Mobiles per 100	ITU	187	82.156	44.938	1.02	232.068
Vendor Position	WCIS	61	1.738	0.854	1	5
Delay from launch	Author's research	84	461.167	153.69	0	900

3.2.1. Dependent Variables

The data for all dependent variables in the analysis was collected by the author over a period of several months in late-2010 and early-2011. After this period checks were

regularly made to monitor for additions to the data or, where information had been missing, new data. Collection of the data required a methodical review of press releases, industry news, and local news sources; in total around 300 individual pieces of evidence were considered. Data collection was focussed in a number of areas; whether the iPhone was launched in a given country, the date of launch in that country, whether it was sold exclusively through a single network operator, and the date at which any exclusivity expired. In addition the identity of the firm which gained exclusivity was recorded in order to be able to match up the collected iPhone data with other datasets.

The collected iPhone dataset is reproduced in appendix B which features a complete list of the websites that were used in production of the dataset.

The elicited variables and the process of collection is outlined below:

Identity of iPhone Countries

Data on the countries in which the iPhone was distributed is the dependent variable used when examining what motivates Apple to sell into particular countries. The decision to sell the iPhone in a country is represented as a binary variable with a value of 0 or 1 for each country in the sample.

To identify those countries in which iPhone was distributed the official Apple website was consulted. The website features a specific set of pages for each country where Apple products are locally sold. If the iPhone was available in a country then these pages would either allow the purchase of the phone (with an accompanying airtime contract) or offer a link to the distributor partner's website (or websites where there were multiple distributing operators). If the iPhone was not officially available in a country then the option to purchase the phone would not be displayed.

In total 109 countries were identified in which the iPhone is launched through at least one official network partner. Of these countries a subset of 84 was isolated where the iPhone was both launched before 2010 (the period covered by the available datasets) and where the countries also have complete information in the main datasets we use.

iPhone Exclusivity

Whether the iPhone was launched exclusively with a single network operator forms the binary first hurdle in the two stage model investigating exclusivity and its duration.

Press releases were favoured as the primary source of evidence in order to determine whether the iPhone was launched exclusively in a country. These press releases were primarily issued by Apple, but sometimes from the relevant network operator. In a very small number of cases it was necessary to rely upon national or industry press. It was found that in 23 of the 84 countries in the usable sample the iPhone was launched competitively with more than one official network partner. In the remaining 61 countries the iPhone was launched exclusively.

Appendix B indicates the sources of evidence that were used.

Duration of Exclusivity

The duration of any exclusivity is the truncated continuous variable used as the second hurdle in the two-stage exclusivity-duration model.

In order to identify the duration of any exclusivity it was necessary to determine, first, the launch date of the iPhone in the relevant countries, and, secondly, the date that the next subsequent vendor started selling the phone. Again, press releases were employed; the initial launch date was in almost all cases included in either Apple's or the network operator's press release. For the dates of second and later vendors there was a greater reliance on press releases from the operator themselves. Finally, as before, in some isolated cases it was necessary to consult local press or industry news sources to learn launch dates.

Using information on dates, the duration variable was calculated as the number of days between the initial launch by an exclusive operator, and the date at which a subsequent operator started selling the iPhone. In the case that the iPhone was launched initially with multiple network operators (competitively) then the duration variable is equal to zero.

The details of all eventual vendors is shown in the dataset in appendix B.

Where exclusivity is ongoing (there is still an exclusive network operator) the duration of exclusivity was taken as the days between launch and September 2013. While this represented an artificial censoring of the data it did not have a probability mass (as at zero) due to the heterogeneity in launch dates. To ensure robustness of the results a second upper censoring was tested which specified the duration for ongoing exclusivity as the days between launch and September 2014 (an extra 365 days); there were no significant differences in the results.

From the above investigations, the identity of the launch operator(s) was isolated; this enabled the matching of the iPhone-specific data with the datasets pertaining to firm-level telecommunications data.

3.2.2. Independent Variables

In order to analyse the determinants of the exclusivity and duration three off-the-shelf datasets were used: World Bank (WB) data on land characteristics and demographics; the World Cellular Information Service (WCIS) dataset on firm-level mobile telecommunications; and International Telecommunications Union (ITU) data on country-level telecommunications indicators. Where necessary the internet search engine Google was also consulted for consistency in determining the geographic location of some countries. Table 3.1 specifies the source of the respective variables.

Because variables needed to be complete for all countries, this influenced the specific choice of variable but, even taking the most complete variables available, the number countries included in the study was reduced from all countries in the world to a workable sample of 187.

Demographic Control Variables

In order to control for the underlying economic and physical characteristics of the countries in the study a range of variables are included.

Country Size and Population Density

In order to control for any effect related to country size and the population, both land area and population density are included. Land area and population density are likely to affect the cost and returns on investment of implementing or upgrading a mobile network. Both these statistics are included in log-form to correct for a left-sided bias.

Country per Capita GDP

The per capita GDP of a country can be considered to be a proxy for demand and thus affects the likelihood of a firm carrying out business in that country. Country GDP is included in the form of GDP per capita in current US dollars. Per-capita GDP has a long right-tail, as such the natural log of per-capita GDP is included in the analysis.

Continent Dummy Variables

In order to capture any region-specific variation in policy, or demand characteristics, dummy variables are included indicating in which continent a country is located. Central American countries are considered as part of North America, while many Pacific Islands are considered to be part of Oceania with Australia. In the interests of consistency where there was ambiguity the search engine Google was consulted and the most prevalent answer from the search results included.

Market structure

In addition to broad demographic effects which are likely to affect the mutual desirability of Apple of network operators to sell the iPhone, the characteristics and competitiveness of the individual markets is predicted to determine the likelihood and duration of any exclusivity arrangements. Market-level data is primarily sourced from the ITU and WCIS datasets.

Number of Firms and Herfindahl–Hirschman Index (HHI)

For each country data concerning the number of active licensed operators and the HHI is included for the year and quarter when the iPhone was launched. If the iPhone was not sold in a country during the study period, the HHI and firm numbers information is included for the final quarter of 2009. Given that many countries since the

introduction of mobile telecommunications have experienced significant consolidation in the number of mobile operators, an operator is considered to be active if they have a positive number of subscriptions.

For each country (i) the HHI is calculated using each active operators' share of the total subscriptions in that country, denoted $s_{i,j}$ where j represents the operator:

$$HHI_i = \sum_{j}^{N} s_{i,j}$$

The level of competition within a country is likely to affect the value to a firm of selling the iPhone. If a market is concentrated then the lack of competition may mean that a dominant firm can earn greater profits from selling non-iPhone handsets relative to firms in highly competitive markets. For network operators in competitive markets the iPhone may act as a key competitive differentiator - making it relatively more valuable to these firms relative to firms facing little competition.

Technology

Variables are included which indicate both the type of technology which is being used in each country and also the penetration of mobile technology.

Competing Standards

As discussed in section 2.2 there are a number of technological standards that are used to transmit mobile telecommunication signals (the main two being GSM and CDMA). These standards render some mobile handsets incompatible with some networks. Section 2.2 indicates that the presence of competing standards leads to switching costs for subscribers in addition to those which would normally exist when switching networks based upon the same technology.

The iPhone was initially incompatible with CDMA networks and was only launched with CDMA compatibility in February 2011. Given the time limitations of the dataset this means that the study is limited only to the launch of the GSM model.

A dummy indicator is included equal to 1 (zero otherwise) if there is more than one compatible standard in operation within a country. Because in many countries there are a number of legacy standards from the early stages of mobile phone development with a very small number of subscribers, the competing standards dummy considers a single standard country to be one where the dominant standard has over 90% of subscriptions. When considering a single standard the competing standards variable considers the entire family of that standard; for example, when considering GSM subscriptions, both GSM and the subsequent W-CDMA standard are included.

Mobile Penetration

In order to capture the use of mobile phones in each country a variable is included which indicates the number of mobile subscriptions per 100 inhabitants. This variable indicates how widespread the use of mobile phones is and, thus, the potential size of the market.

Other Variables

Two variables are included which are used only in the two-stage model investigating exclusivity and duration to provide further information about the iPhone launch and the firm which is allocated exclusivity.

Vendor Position

Vendor position is used to investigate whether the market position of the firm which is allocated exclusivity determines the duration of the exclusivity agreement. Necessarily it is only observed in the case that an exclusivity strategy was pursued.

Time

The variable 'Delay from launch' is included which represents the number of days between the initial launch of the iPhone in the US in 2007, and the launch of the iPhone in each country. This time aspect is designed to capture the effect of uncertainty (common to many of the theoretical models of section 1.3) diminishing over time. It is

necessarily included only for those countries where the iPhone was launched.

3.3. Econometric Specification

The empirical investigations in the next section focus on two themes: the decision of Apple to sell the iPhone in a particular territory; and the decision to contract exclusively to sell through a single network operator. In both cases a cross-section of up to 187 countries is analysed using the demographic and telecommunications-specific variables outlined in the previous section.

This section outlines the specification of the models which are tested using the econometric methodologies of section 3.1. Also outlined is the rationale for testing using both a full and restricted sample, and also descriptions of some of the robustness testing which is applied to the results.

3.3.1. Entry

In analysing the entry decision section 3.1 explained that the approach being taken is to treat the entry decision as binary where a value of 1 implies the iPhone was sold in a particular country, zero otherwise. To this effect a Probit model is employed.

The analysis examines several specifications of the entry model; focussing on the case where only demographic control variables are considered, up to a model containing both demographic and telecommunication variables. Denoting E_i as the underlying latent variable determining launch in country i, the specifications used are as follows:

$$\text{(A)} \quad E_i = \alpha_0 + \alpha_1 \text{LogLandArea}_i + \alpha_2 \text{LogPopDensity}_i + \alpha_3 \text{LogGDPCapita}_i + \varepsilon_i$$

$$\text{(B)} \quad E_i = \alpha_0 + \alpha_1 \text{LogLandArea}_i + \alpha_2 \text{LogPopDensity}_i + \alpha_3 \text{LogGDPCapita}_i + \\ + \sum_{\alpha_4}^{\alpha_9} \text{Continent}_i + \varepsilon_i$$

$$\text{(C)} \quad E_i = \alpha_0 + \alpha_1 \text{LogLandArea}_i + \alpha_2 \text{LogPopDensity}_i + \alpha_3 \text{LogGDPCapita}_i + \\ + \sum_{\alpha_4}^{\alpha_9} \text{Continent}_i + \alpha_{10} \text{Num.Firms}_i + \alpha_{11} \text{HHI}_i + \varepsilon_i$$

$$\text{(D)} \quad E_i = \alpha_0 + \alpha_1 \text{LogLandArea}_i + \alpha_2 \text{LogPopDensity}_i + \alpha_3 \text{LogGDPCapita}_i + \\ + \sum_{\alpha_4}^{\alpha_9} \text{Continent}_i + \alpha_{10} \text{Num.Firms}_i + \alpha_{11} \text{HHI}_i + \alpha_{12} \text{Comp.Standards}_i + \\ + \alpha_{13} \text{MobilesPer100}_i + \varepsilon_i$$

In each of the specifications (A) to (D) variables are iteratively added to the regression to identify their additional influence on the decision to sell the iPhone. The coefficients α_4 to α_9 represent the influence of the dummy variables asscociated with the region in which the country is based.

Population effects

The sample of 187 countries used in the investigation contains a number of countries with low populations. Where a country has a low population, or a small size, then it is likely that operators in these countries are not faced with the same set of constraints; the choice set of the firms in terms of investment, or the nature of competition, is likely to be different.

As such, the above regressions (A) to (D) are repeated with a restricted sample where the population is in excess of 499,000. Any significant change in the results will indicate that the relationship between the dependent and independent variables is different for the subset of smaller countries. The results from these restricted-sample regressions are included as specifications (E) to (H); they are unchanged in structure from the above but for the reduced sample size.

Goodness of Fit

The above specifications (A) to (D), and (E) to (H), are constructed by iteratively adding relevant variables to determine their effect. Because the absolute value of the log-likelihood is non-increasing in the number of variables there exists a danger of 'over-fitting' the model through the inclusion of irrelevant variables. Burnham and Anderson [2004] observe the trade-off between parsimony which can result in biased models, and those over-fitted models where significance is lost or otherwise there is spurious identification of significant effects. In order to illustrate that the addition of extra variables results in a better fitting model Akaike's Information Criterion (AIC) is employed. The AIC improves with associated decreases in the absolute value of the log-likelihood, but (all else being equal) degrades with the size of the model as measured by the number of included variables.

In a maximum likelihood model, such as the probit, the AIC formula is expressed

as below, where a smaller value of AIC implies a better fitting model:

$$AIC = 2Df - 2\ln(L)$$

Where Df represents the degrees of freedom of the model and $\ln(L)$ is the log-likelihood of the model.

For all of the regressions (A) to (H), the specification of the models is tested and the results reported.

3.3.2. Exclusivity

Two regression techniques are used in the investigation of exclusivity; the Tobit model and Cragg's Tobit alternative. The Tobit is restrictive in a number of assumptions but by testing these assumptions it allows inferences to be made about whether the determinants of the durability of exclusive supply arrangements are the same factors which influence its initial imposition. The Cragg model conversely allows much greater flexibility.

The Tobit model

The Tobit model is used to determine whether the same relationship governs both the decision to supply exclusively and the duration of the exclusivity. The specification of the Tobit model employed is shown below:

$$\begin{aligned}(\text{I}) \quad \text{Duration}_i = {} & \beta_0 + \beta_1 \text{LogLandArea}_i + \beta_2 \text{LogPopDensity}_i + \beta_3 \text{LogGDPCapita}_i + \\ & + \sum_{\beta_4}^{\beta_9} \text{Continent}_i + \beta_{10} \text{Num.Firms}_i + \beta_{11} \text{HHI}_i + \beta_{12} \text{Comp.Standards}_i + \\ & + \beta_{13} \text{MobilesPer100}_i + \beta_{14} \text{LaunchDelay} + \varepsilon_i\end{aligned}$$

Section 3.1 describes that the Tobit model is used to overcome issues relating to the truncation of a continuous variable by utilising a hurdle where $\text{Duration}_i > 0$. This

restricts the analysis in that the same process must govern both whether Duration_i exceeds zero, and its ultimate magnitude. The relationship between drivers of exclusivity and duration form one of the key strands of investigation, thus this assumption is tested using the Lagrange Multiplier test of Lin and Schmidt [1984] and results discussed.

With the same rationale as in the case for entry, the Tobit model is performed with both the full sample of 84 countries where the iPhone was launched, and the population-restricted sample of 81 countries; resulting in, respectively, specifications (I) and (J).

Cragg's Tobit alternative

In addition to the Tobit model Cragg's Tobit alternative is also used to investigate exclusivity; this allows separability of the processes which govern exclusivity, and those determining its duration. Cragg's model utilises both a probit form for the initial exclusivity decision, and a truncated normal regression for the continuous duration variable. As such, each of the following specifications has a regression representing each of the components; where X_i is the underlying latent variable determining exclusivity in country i, and Duration_i the length of the exclusivity period:

The regressions (K), (L), and (M), based upon Cragg's Tobit alternative, are also replicated for the restricted sample; denoted (N), (O), and (P).

The following section outlines and interprets the key results from the various models. A discussion of the results with respect to a-priori expectations follows.

(K)

$$
\begin{aligned}
X_i &= \gamma_0 + \gamma_1 \text{LogLandArea}_i + \gamma_2 \text{LogPopDensity}_i + \gamma_3 \text{LogGDPCapita}_i + \\
&\quad + \sum_{\gamma_4}^{\gamma_9} \text{Continent}_i + \varepsilon_i \\
\text{Duration}_i &= \eta_0 + \eta_1 \text{LogLandArea}_i + \eta_2 \text{LogPopDensity}_i + \eta_3 \text{LogGDPCapita}_i + \\
&\quad + \sum_{\eta_4}^{\eta_9} \text{Continent}_i + \upsilon_i
\end{aligned}
$$

(L)

$$
\begin{aligned}
X_i &= \gamma_0 + \gamma_1 \text{LogLandArea}_i + \gamma_2 \text{LogPopDensity}_i + \gamma_3 \text{LogGDPCapita}_i + \\
&\quad + \sum_{\gamma_4}^{\gamma_9} \text{Continent}_i + \varepsilon_i \\
\text{Duration}_i &= \eta_0 + \eta_1 \text{LogLandArea}_i + \eta_2 \text{LogPopDensity}_i + \eta_3 \text{LogGDPCapita}_i + \\
&\quad + \sum_{\eta_4}^{\eta_9} \text{Continent}_i + \eta_{10} \text{Num.Firms}_i + \eta_{11} \text{HHI}_i + \eta_{12} \text{Comp.Standards}_i + \\
&\quad + \eta_{13} \text{MobilesPer100}_i + \eta_{14} \text{LaunchDelay} + \eta_{15} \text{VendorPos.} + \upsilon_i
\end{aligned}
$$

(M)

$$
\begin{aligned}
X_i &= \gamma_0 + \gamma_1 \text{LogLandArea}_i + \gamma_2 \text{LogPopDensity}_i + \gamma_3 \text{LogGDPCapita}_i + \\
&\quad + \sum_{\gamma_4}^{\gamma_9} \text{Continent}_i + \gamma_{10} \text{Num.Firms}_i + \gamma_{11} \text{HHI}_i + \gamma_{12} \text{Comp.Standards}_i + \\
&\quad + \gamma_{13} \text{MobilesPer100}_i + \gamma_{14} \text{LaunchDelay} + \varepsilon_i \\
\text{Duration}_i &= \eta_0 + \eta_1 \text{LogLandArea}_i + \eta_2 \text{LogPopDensity}_i + \eta_3 \text{LogGDPCapita}_i + \\
&\quad + \sum_{\eta_4}^{\eta_9} \text{Continent}_i + \eta_{10} \text{Num.Firms}_i + \eta_{11} \text{HHI}_i + \eta_{12} \text{Comp.Standards}_i + \\
&\quad + \eta_{13} \text{MobilesPer100}_i + \eta_{14} \text{LaunchDelay} + \eta_{15} \text{VendorPos.} + \upsilon_i
\end{aligned}
$$

3.4. Results and Discussion

The results from the investigation indicate that, as proposed, there are distinctions between the mechanisms which determine imposition and duration of exclusivity restraints. Furthermore, in examining the duration of the agreements there is significant evidence that both the level of competition and the presence of competing standards have a positive relationship with the duration of exclusivity.

As outlined in the preceding sections, two investigations are carried out: determinants of entry; and determinants of exclusivity. In each case a different but appropriate method of econometric analysis has been employed. Furthermore, in each case investigations were carried out on both a full sample of countries, and also a restricted sample which eliminated those with a population less than 500,000. The results for both samples are included below.

3.4.1. Population Effects

The decision to investigate two samples - separated by population - is driven by the prediction that the operation of mobile telecommunications is subject to different constraints in smaller countries vis-a-vis larger ones. These constraints are likely to be different distributions of income, different challenges in terms of network infrastructure, and differences in the nature or strength of competition.

In order to test this prediction the sample of countries is split into subsets of 'small' (according to an upper population limit of 499,999 for a small country) and other countries. For each of the subsets of countries the set of continuous variables analysed in the models (which is assumed to be a proxy of the different constraints firms face) is compared. This is subjected to a Mann-Whitney test to determine whether they are drawn from the same distribution.

The Mann-Whitney test is used to determine whether a set of observed results are comparable to a wider distribution. It is set against a null hypothesis that they are drawn from the same underlying distribution. In the case that the underlying distributions of the variables are determined to be significantly different from each other the null hypothesis is rejected.

Table 3.2.: Mann-Whitney test of population restriction

Variable	Mean Small	Mean Others	MW U	P$>|U|$
Log Land Size	7.038	12.01	7.442	0.000***
Log Pop. Density	4.656	4.155	-2.412	0.016**
Log GDP per Capita	9.269	8.295	-2.912	0.004***
Mobiles per 100	94.099	80.052	-1.73	0.084*
Num. Firms	2.036	3.761	5.556	0.000***

hline

Table 3.2 indicates that the mean values for the variables are different between the smaller and other countries' continuous variables. The Mann-Whitney U-value for each of the variables is also significant at a 1% level in the case of land size (smaller population countries are also smaller), GDP per capita (smaller countries are richer on a per capita basis), and the number of competing network operators (less in smaller countries).

These results support the additional analysis of a restricted sample. For robustness different population thresholds were also considered, but ultimately rejected based upon a balance of Mann-Whitney scoring and intuition on what the population censoring is designed to achieve.

3.4.2. Entry Decision

A Probit model is utilised to examine the binary nature of Apple's decision to sell their iPhone in particular countries. It includes both demographic and telecommunication-based independent variables. As mentioned above, the model is tested using a full and a restricted sample. The results are shown in table 3.3 while the marginal effects for specifications (D) and (H) are shown in table 3.4.

Table 3.3 indicates that under both the full and restricted sample, irrespective of model specification, the coefficients associated with raw demographic variables (α_1, α_2, and α_3) are significant at the 1% level. The probability of the iPhone being sold was higher in those territories which were bigger, more densely populated, and richer in terms of per capita GDP.

Table 3.3.: Probit determinants of entry

		Availability of iPhone							
Independent variables	Coefficient	Full sample (A)	(B)	(C)	(D)	(E)	Restricted sample (F)	(G)	(H)
Log Land Area	α_1	0.426***	0.509***	0.537***	0.559***	0.337***	0.428***	0.434***	0.455***
		(0.068)	(0.081)	(0.096)	(0.1)	(0.085)	(0.094)	(0.113)	(0.119)
Log Pop. Density	α_2	0.464***	0.645***	0.672***	0.692***	0.369***	0.549***	0.558***	0.57***
		(0.1)	(0.123)	(0.142)	(0.149)	(0.11)	(0.132)	(0.153)	(0.16)
Log GDP/Capita	α_3	0.603***	0.611***	0.601***	0.631***	0.593***	0.612***	0.605***	0.583***
		(0.089)	(0.113)	(0.116)	(0.156)	(0.091)	(0.116)	(0.119)	(0.167)
Africa	α_4		-0.263	-0.164	-0.018		-0.114	0.029	0.18
			(0.392)	(0.407)	(0.423)		(0.403)	(0.424)	(0.438)
North America	α_5		-0.13	0.044	0.279		0.457	0.674	0.932
			(0.41)	(0.43)	(0.459)		(0.495)	(0.527)	(0.56)
South America	α_6		0.578	0.517	0.712		0.639	0.624	0.817
			(0.603)	(0.603)	(0.635)		(0.594)	(0.596)	(0.626)
Asia	α_7		-1.188***	-1.144***	-1.059***		-0.974**	-0.92**	-0.816**
			(0.376)	(0.385)	(0.397)		(0.382)	(0.391)	(0.404)
Aus & Oceania	α_8		-0.183	0.102	0.423		-0.076	0.302	0.631
			(0.879)	(1.084)	(1.04)		(0.943)	(1.199)	(1.151)
Europe	α_9		(omitted)	(omitted)	(omitted)		(omitted)	(omitted)	(omitted)
Num. Firms	α_{10}			-0.168	-0.144			-0.137	-0.115
				(0.11)	(0.114)			(0.112)	(0.116)
HHI	α_{11}			-2.408**	-2.4*			-2.509**	-2.387*
				(1.204)	(1.245)			(1.263)	(1.315)
Competing Standards	α_{12}				-0.634				-0.571
					(0.486)				(0.499)
Mobiles per 100	α_{13}				0.001				0.003
					(0.005)				(0.005)
Constant	α_0	-12.045***	-13.456***	-12.192***	-12.983***	-10.46***	-12.232***	-10.749***	-11.267***
		(1.586)	(2.023)	(2.195)	(2.391)	(1.741)	(2.139)	(2.339)	(2.497)
n		187	187	187	187	159	159	159	159
Log Likelihood		-83.055	-75.125	-72.888	-70.729	-76.662	-69.215	-67.04	-64.679
AIC		174.111	168.25	167.776	167.458	161.323	156.43	156.081	155.357

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

GDP was included as a proxy for the overall level of demand within a country and has the expected sign. Countries with a higher level of demand are likely to be more profitable, both downstream and consequently upstream.

Higher population density means that infrastructure cost per user is lower, however the link between this and the economic rationale for the introduction of the iPhone is not clear. Where the fixed cost of infrastructure per user is lower this would reduce the cost associated with network infrastructure upgrades (if needed). However the likely explanation is that these networks are simply better developed.

Land size, having controlled for population density and GDP, does not immediately lend itself to a theory supporting the sale of the iPhone. Land size is negatively correlated with both GDP per capita and population density (see Appendix A).

In terms of geographic controls, countries in Asia were less likely to sell the iPhone, relative to Europe – the geographic base variable. This confirmed the patterns which were observed in the data.

In terms of telecom-specific variables, α_{11} - the coefficient associated with HHI is significant at either 5 or 10% level in, respectively, specifications C and D (and also G and H). The inclusion of a variable representing the number of firms means that HHI is interpreted as a measure purely of the inequality of firm markets shares.

Persistent inequality in firm market shares can be perceived as where markets are less competitive. This links the notion of market competitiveness with firms' likelihood (or lack of) of selling the iPhone. The rationale for this outcome may lie in the iPhone as a competitive tool; networks hope to attract customers by selling the iPhone. If this is not the case then networks may feel little need to sell the iPhone. On the basis that every sale of an iPhone has an opportunity cost in terms of another variety handset that could be sold. If competition is not strong, and the unit profit from an iPhone is less than other available handsets, then the incentives to sell the iPhone will be weak.

None of the other telecommunications-specific coefficients are significant at 10% or higher in any of the specifications. Given the interpretation of the variable 'Mobiles per 100' as an indicator of the development and penetration of the mobile market, this

suggests that this had little bearing on the sale of the iPhone in a given country.

Result 1 *The determinants of the sale of the iPhone in a given country is dominated by basic demographic factors of land size, population density, and GDP per capita. Of the telecom specific variables included, only the measure of inequality of firm sizes is significant; indicating that the iPhone was less likely to be sold in concentrated markets.*

Entry Probit Goodness of Fit

In comparing the model specifications, because the log-likelihood is non-decreasing in the number of variables added, Akaike's Information Criterion (AIC) is used. This moderates the log-likelihood based upon the number of variables which are added to avoid spurious conclusions from proliferation of explanatory items. The AIC statistic, where smaller is better, indicates that the model improves with the addition of the extra variables, even where individually the variables are insignificant.

The smaller AIC results indicate that under both restricted and unrestricted samples the full models ((D) and (H)) provide the best explanation of the data. Although the telecom-specific variables are of limited significance, the model performs better with their inclusion.

Entry Probit Marginal Effects

The marginal effects for a unit change in the included variables on the probability are included in table 3.4.

The significance of the marginal effects naturally mirrors the results in the table 3.3. They show that an increase of 20% in the HHI of a country (i.e. from 0.2 to 0.4) would reduce the probability of the iPhone being sold by around 10%. Unit increases in the log demographic variables indicate an increased likelihood of the sale of the iPhone by between (approximately) 10 and 15%. One must be wary of interpreting these results too literally. The demographic variables are transformed and as such a unit increase does not imply a linear increase in their respective underlying value.

Table 3.4.: Entry Probit Marginal Effects

Marginal effect	Full sample (D)	Restricted sample (H)
Log Land Area	0.117***	0.103***
	(0.015)	(0.023)
Log Pop. Density	0.145***	0.129***
	(0.025)	(0.032)
Log GDP/Capita	0.132***	0.132***
	(0.028)	(0.033)
Africa	-0.004	0.041
	(0.089)	(0.099)
North America	0.058	0.21*
	(0.096)	(0.124)
South America	0.149	0.184
	(0.131)	(0.139)
Asia	-0.221***	-0.184**
	(0.078)	(0.088)
Aus & Oceania	0.088	0.142
	(0.217)	(0.259)
Europe	(omitted)	(omitted)
Num. Firms	-0.03	-0.026
	(0.023)	(0.026)
HHI	-0.502**	-0.539*
	(0.251)	(0.287)
Competing Standards	-0.133	-0.129
	(0.1)	(0.111)
Mobiles per 100	0	0.001
	(0.001)	(0.001)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

3.4.3. Exclusivity and duration

The study of exclusivity is formed of two parts: evidence that the determinants of the imposition of exclusive distribution agreements differ from those determining its duration; and the study of the drivers of both stages examined with respect to the theoretical predictions.

Modelling exclusivity and duration as a two distinct components in the same process requires a different approach to standard regression models. Thus, in this investigation

two-stage models are used; the Tobit model, and Cragg's Tobit alternative. Two stage models allow the analysis of truncated or censored variables. Specifically, where a variable is censored at zero a two-stage model allows analysis of the conditions required breach the zero threshold, and the subsequent analysis of determinants of the final magnitude of the variable.

The Tobit approach

One of the core aims of this part of the thesis is to determine whether the duration of an exclusivity agreement is determined by the same variables which determine its imposition. The core assumption of the Tobit model is that a single process governs both the breach of the threshold and the final magnitude of the dependent variable. By testing the Tobit assumptions using the Lin and Schmidt [1984] Lagrange Multiplier test it can be determined whether separate processes are in action in exclusivity. The results from the Tobit estimation are shown in table 3.5 where model *(I)* represents the unrestricted sample of countries and *(J)* the limited sample. The Likelihood Ratio test scores are also included for each specification, measured against the null that the dependent variables have no explanatory power.

The findings from the Tobit model can only be accepted in the case that the Tobit is the correct specification and thus that a single process governs both stages of the model. In the present investigation this would imply that exclusivity and its duration are governed by the same mechanism. In order to test this assumption the Lagrange Multiplier (LM) test of Lin and Schmidt [1984] is used. The results are shown in in table 3.6 which compares the LM test score against the null that the Tobit is correctly specified.

The LM test scores for both restricted and unrestricted model are significant at greater than 1% level. This means that we reject the null hypothesis that the Tobit is correctly specified and instead assume that the results of the two hurdles (exclusivity and duration) and governed by separate processes.

Result 2 *The imposition and the duration of exclusive distribution agreements are governed by different processes. Where the conditions for imposition are strong this does not imply that the resulting exclusive distribution agreement will be durable, and*

Table 3.5.: Tobit exclusivity model

Independent variables	Coefficient	Duration of exclusivity Full sample (I)	Restricted sample (J)
Log Land Area	β_1	-145.435***	-219.833***
		(50.962)	(56.823)
Log Pop. Density	β_2	-206.696**	-278.421***
		(81.301)	(82.879)
Log GDP/Capita	β_3	-166.968**	-103.387
		(81.621)	(81.813)
Africa	β_4	478.504	425.414
		(289.752)	(283.316)
North America	β_5	-460.381*	-551.255**
		(264.564)	(261.742)
South America	β_6	-1127.745***	-1103.342***
		(311.925)	(300.845)
Asia	β_7	73.9	129.327
		(249.364)	(243.808)
Aus & Oceania	β_8	-553.277	-645.667
		(525.507)	(509.215)
Europe	β_9	(omitted)	(omitted)
Num. Firms	β_{10}	35.115	55.039
		(53.93)	(52.687)
HHI	β_{11}	1623.16*	1631.735*
		(870.271)	(851.644)
Competing Standards	β_{12}	595.601**	578.71**
		(272.922)	(263.654)
Mobiles per 100	β_{13}	0.791	-1.942
		(2.776)	(2.901)
LaunchDelay	β_{14}	-0.397	-0.338
		(0.575)	(0.555)
Constant	β_0	4113.576***	4947.083***
		(1403.69)	(1396.699)
$\hat{\sigma}$		573.745***	552.837***
		(55.418)	(54.2)
n		84	81
LogLikelihood		-493.347	-474.317
LR		46.36	50.55
P(LR)> $\chi^2(13)$		0	0

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

vice versa.

Because the Tobit specification is rejected the analysis of the results is suitably brief.

In table 3.5 there are a number of variables which are found to be significant. The coefficients associated with the key demographic control variables are all negative, though

Table 3.6.: Tobit Lagrange Multiplier Test

Sample	LM Score	10%	5%	1%
Full (I)	21.474	4.41	6.118	10.189
Restricted (J)	22.49	4.268	6.374	11.681

GDP per capita is only significant in the non-restricted sample of countries (at a 10% level). The non-separability of exclusivity and duration decision in the Tobit implies that expected duration is shorter given larger and densely populated countries. The same conclusion can be drawn of both countries in North and South America relative to Europe (the base category for geographical location).

Both coefficients for market concentration (HHI) and the presence of competing standards are positive and significant (at 10% and 5% levels respectively). These results are representative of the market structures in the presence of either heavy concentration or where there are multiple technological standards in operation.

On the basis of both log likelihood and likelihood ratio test scores the restricted sample model, as in the rest of the analyses, is a better fit relative to that for the full sample.

Cragg's Tobit alternative

The rejection of the Tobit specification in Result 2 motivates the use of Cragg's Tobit alternative which allows different processes to govern each stage of the analysis. Like the Tobit, Cragg's model still controls for the truncated nature of the duration variable.

Table 3.7 shows the results for Cragg's Tobit alternative applied to the exclusivity and duration data. The two hurdles are estimated separately using first a Probit approach, and second a linear regression of a truncated normal variable, calculated using maximum likelihood. For the full sample and the restricted sample of countries three specifications are tested: a demographic-only model; a full model using all variables; and a hybrid with telecommunication variables in the second stage. For each of the specifications Akaike's Information Criterion is reported in addition to the overall log likelihood (LL). The likelihood ratio test scores for the first-stage Probit are also reported. The variable $\hat{\sigma}$ is the estimate of the variance of the second-stage censored regression.

Table 3.7.: Results from Cragg's Tobit alternative

Independent variables	Coefficient	Exclusivity and duration hurdle					
		Full sample			Restricted sample		
		(I)	(J)	(K)	(L)	(M)	(N)
		Tier1=Exclusivity					
Log Land Area	γ_1	-0.172*	-0.172*	-0.15	-0.311**	-0.311**	-0.421**
		(0.103)	(0.103)	(0.224)	(0.132)	(0.132)	(0.182)
Log Pop. Density	γ_2	-0.438**	-0.438**	-0.422*	-0.664**	-0.664**	-0.777**
		(0.211)	(0.211)	(0.127)	(0.26)	(0.26)	(0.31)
Log GDP/Capita	γ_3	0.052	0.052	0.11	0.153	0.153	0.329
		(0.176)	(0.176)	(0.236)	(0.194)	(0.194)	(0.26)
Africa	γ_4	0.874	0.874	0.872	1.134	1.134	0.731
		(0.778)	(0.778)	(0.909)	(0.833)	(0.833)	(0.927)
North America	γ_5	0.034	0.034	-0.363	0.071	0.071	-0.583
		(0.529)	(0.529)	(0.658)	(0.553)	(0.553)	(0.721)
South America	γ_6	-1.613***	-1.613***	-2.009***	-1.653***	-1.653***	-2.096***
		(0.6)	(0.6)	(0.68)	(0.622)	(0.622)	(0.716)
Asia	γ_7	0.884	0.884	0.849	1.233*	1.233*	1.21*
		(0.597)	(0.597)	(0.687)	(0.677)	(0.677)	(0.734)
Aus & Oceania	γ_8	-1.408	-1.408	-2.069*	-1.827*	-1.827*	-2.612**
		(1.007)	(1.007)	(1.232)	(1.066)	(1.066)	(1.283)
Europe	γ_9	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
Num. Firms	γ_{10}			-0.023			0.022
				(0.129)			(0.138)
HHI	γ_{11}			3.499			2.495
				(2.642)			(2.796)
Comp.Standards	γ_{12}			0.858			0.755
				(0.659)			(0.649)
Mobiles per 100	γ_{13}			0.001			-0.011
				(0.008)			(0.009)
LaunchDelay	γ_{14}			0			0
				(0.002)			(0.002)
Constant1	γ_0	4.137	4.137	1.916	5.88*	5.88*	6.148
		(2.811)	(2.811)	(4.08)	(3.098)	(3.098)	(4.711)
		Tier2=Duration					
Log Land Area	η_1	-76.987**	-119.593***	-119.593***	-92.806**	-141.301***	-141.301***
		(36.946)	(40.616)	(40.616)	(37.575)	(41.359)	(41.359)
Log Pop. Density	η_2	-72.171	-101.311*	-101.311*	-83.284	-115.459**	-115.459**
		(60.294)	(60.82)	(60.82)	(58.909)	(58.963)	(58.963)
Log GDP/Capita	η_3	-164.834***	-251.131***	-251.131***	-149.987***	-225.75***	-225.75***
		(51.201)	(62.828)	(62.828)	(50.402)	(60.67)	(60.67)
Africa	η_4	374.605*	362.06*	362.06*	388.781*	331.024*	331.024*
		(203.497)	(193.699)	(193.699)	(199.185)	(190.646)	(190.646)
North America	η_5	6.195	-393.143*	-393.143*	-12.165	-464.744**	-464.744**
		(177.525)	(219.451)	(219.451)	(173.141)	(215.427)	(215.427)
South America	η_6	32.453	-132.501	-132.501	27.818	-171.443	-171.443
		(309.551)	(305.363)	(305.363)	(301.408)	(295.451)	(295.451)
Asia	η_7	-72.642	-195.048	-195.048	-84.968	-215.177	-215.177
		(168.507)	(181.683)	(181.683)	(164.431)	(176.102)	(176.102)
Aus & Oceania	η_8	478.191	-21.862	-21.862	431.281	-112.918	-112.918
		(410.114)	(440.621)	(440.621)	(400.611)	(428.996)	(428.996)
Europe	η_9	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
Num. Firms	η_{10}		94.47**	94.47**		98.852**	98.852**
			(42.03)	(42.03)		(40.711)	(40.711)
HHI	η_{11}		1077.373*	1077.373*		1281.305**	1281.305**
			(637.755)	(637.755)		(626.579)	(626.579)
Comp.Standards	η_{12}		508.144**	508.144**		530.46**	530.46**
			(231.921)	(231.921)		(223.771)	(223.771)
Mobiles per 100	η_{13}		2.443	2.443		1.684	1.684
			(2.15)	(2.15)		(2.144)	(2.144)
Delay from launch	η_{14}		-0.239	-0.239		-0.269	-0.269
			(0.42)	(0.42)		(0.406)	(0.406)
Vendor Position	η_{15}		-88.503	-88.503		-65.115	-65.115
			(64.626)	(64.626)		(64.134)	(64.134)
Constant2	η_0	3602.241***	4281.804***	4281.804***	3724.546***	4358.935***	4358.935***
		(851.357)	(1016.889)	(1016.889)	(842.981)	(988.622)	(988.622)
$\hat{\sigma}$		391.029***	348.274***	348.274***	382.296***	337.668***	337.668***
		(41.749)	(35.981)	(35.981)	(40.813)	(34.884)	(34.884)
n		84	84	84	81	81	81
LL		-484.995	-478.225	-475.627	-465.661	-458.762	-455.986
LR		19.36	19.36	24.55	23.51	23.51	29.06
P(LR)> χ^2		0.013	0.013	0.026	0.003	0.003	0.006
AIC		1007.991	1006.45	1011.253	969.322	967.52	971.972

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

Before analysing the results of Cragg's Tobit alternative in depth, there are a number of observations which can be made concerning the model specification. First, the restricted sample models are a better fit of the data than the unrestricted (as measured by the absolute value of the log likelihood and AIC) - this again vindicates restricting the sample. Second, the Likelihood Ratio scores indicate that the demographic-only specifications for the first stage are more effective than the full model under both full and restricted samples. Third, associated with the differences in the LR test scores for the first-stage; the AIC statistic indicates that specifications (J) and (M) provide a better fit than their counterparts for the two samples. Given that Akaike's Information Criterion penalises the inclusion of irrelevant variables, it can be concluded that the addition of telecom-specific variables in the first stage do not add to the explanatory power of the model.

The following analysis of the variables focusses on the restricted sample results, though consideration is given to the full sample where appropriate.

In the first stage the determination of an exclusive distribution agreement the variables associated with both land area (γ_1) and population density (γ_2) are negative and significant in all specifications. This fits with the stylised facts from the observed data where large countries often have regional telecommunication networks - such that exclusivity deals may be made on a regional basis. Secondly, this fits with the notion that there is less scope for free-riding on promotional effort, as per Mathewson and Winter [1984], in large sparsely populated countries. This is a reasonable assumption since spillovers in information will be more pronounced where population density is highest. The persistence of the significance of some geographical identifiers across specifications confirms trends which were present in the data such as the tendency of not entering into exclusive distribution in South America.

No telecommunications-specific variables proved to have a statistically significant impact on the probability of the introduction of an exclusive distribution agreement. In the theoretical literature [Rey and Tirole, 1986] suggests that demand or cost uncertainty will influence the choice of exclusivity. Given the use of 'LaunchDelay' as a proxy for the passage of time, over which uncertainty would be resolved, it was expected that this would have significance. The near-zero result on the time from launch (γ_{14}) emphatically denies this prediction.

The results pertaining to the duration of an exclusivity agreement present a number of variables which are significant; both demographic and telecom-related. The paucity of literature concerning the determinants of duration in exclusivity agreements limits the scope for a-priori expectations regarding the and magnitude or sign of the coefficients. The results are discussed below.

Even for controlling for regional differences, which are likely to be highly correlated with some demographic measures, all key demographic indicators are negative and significant at 5% or better. Comparatively larger, more populous, and wealthier countries are likely to have shorter duration exclusivity restraints.

One issue that Apple may have faced in its exclusive contracting arrangements is that relating to switching costs or barriers to switching which are covered in detail in the literature relating to switching in section 4.2.1. To this effect section 2.1 explained that the nature of subscriptions and long-term relationships in mobile telecommunications mean that switching costs are particularly prevalent. By contracting with a single network operator Apple may have limited its potential market to only those currently subscribed to that operator and those willing to switch. Where incomes are higher the opportunity cost of such exclusivity is likely to be higher. Similarly in larger countries with regional patterns of provision the barriers to switching will be very high for individuals in areas not intensively covered by the exclusive supplier.

A second interpretation for the significance of GDP lies in taking an alternative view. Where GDP per capita is very low the potential market may be small and network infrastructure underdeveloped. In which case, if there are fixed costs for an operator in providing infrastructure to support iPhone, the market may only be able to feasibly sustain a single provider to guarantee a return on necessary investment, as per Lafontaine and Slade [2005].

Geographic indicators are also significant to varying degrees; indicating that, relative to Europe, North American (including Caribbean and Central America) countries were likely to have shorter duration, while African countries longer, though their inclusion is motivated by a need to control for regional policy rather than draw conclusions based upon their result.

Telecom Variables and Duration

A number of telecom-specific variables are significant in the second stage of Cragg's model. Similarly to the Tobit in table 3.5, coefficients associated with market concentration and competing standards ($\eta 11$ and $\eta 12$, respectively) are persistently significant at a 5% level. In addition the number of firms active in the market is also significant at a 5% level - indicated by the coefficient η_{10}.

Competing Standards

Where a market has competing standards, the different technological standards are often used by different firms. The earlier discussion focussed on competing standards as a source of switching costs in mobile telecommunications; competing standards exaggerate the switching costs that already exist concerning changing provider.

The use of the iPhone as a competitive lever to differentiate a firm relies upon the ability of that firm to attract customers from rival providers. Where switching costs exist this will delay or inhibit consumers from switching to that operator which offers the iPhone. The nature of switching costs in telecommunications is also closely linked to the nature of fixed-term subscriptions. They are not constant over time and will be lower at periods near the end of the fixed-term. It naturally follows that, in the presence of such switching costs, an exclusive provider may require a longer period of exclusivity in order to fully exploit the competitive advantage inherent in offering the iPhone.

Concentration and Firm Numbers

By controlling for firm number in the market in all the approaches (through the inclusion of the relevant variable) HHI can be interpreted as being primarily the measure of inequality of firm sizes. Thus, from the entry investigation in table 3.3, we observed that markets with unequal market shares were less likely to sell the iPhone. From table 3.7 HHI has no bearing on the actual likelihood of exclusivity but, conditional on the case that exclusivity is imposed, this exclusivity is likely to be significantly longer in markets characterised by uneven market shares. The insignificance of the variable indicating the market position of the firm that sells the iPhone (η_{15} means that there is no pattern that either the dominant firm in the market, nor smaller firms are selling

the iPhone). This makes the drawing of conclusions over the competitive aspects of the observed long duration.

In addition, where a market is unevenly distributed, long-term contracting with a dominant provider may provide access to the majority of the market, reducing the need to contract with further networks after a time.

A strong result is that the coefficient associated with the number of firms (η_{10}) is positive and persistently significant at 5% across specifications. Where there are many firms, this is significantly likely to increase the duration of exclusivity restraints. This result on firm numbers has more basis in the information spillover theories from the literature such as Mathewson and Winter [1984]. The finding supports the view that where there are more firms competing, spillovers in advertising are highest. In this case Apple has the incentive to maintain exclusivity to ensure that firms expend appropriate effort in advertising.

None of the remaining industry-specific variables are significant, this prompts the final result of the investigation:

Result 3 *The decision to deal exclusively is dominated by demographic variables, whereas the duration of exclusivity is determined by a range of variables relating to technical and competitive aspects. Specifically, where the number of networks competing in the market is highest we observe longer exclusivity periods. Longer periods of exclusivity are also associated with market concentration and competing standards.*

Conclusion

This part of the thesis set out with several objectives: to understand the determinants of Apple's decision to sell the iPhone in certain countries; to understand the determinants of the decision and duration of any exclusive distribution agreements; and to show that the decision to deal exclusively and decisions over duration are not necessarily on-and-the-same decision.

In the process of the achieving the above objectives the investigation has returned three key results:

Result 1 *The determinants of the sale of the iPhone in a given country is dominated by basic demographic factors of land size, population density, and GDP per capita. Only the measure of inequality of firm sizes is significant of the telecom specific variables, indicating that the iPhone was less likely to sold in concentrated markets.*

Result 2 *The imposition and the duration of exclusive distribution agreements are governed by different processes. Where the conditions for imposition are strong this does not imply that the resulting exclusive distribution agreement will be durable, and vice versa.*

Result 3 *The decision to deal exclusively is dominated by demographic variables, whereas the duration of exclusivity is determined by a range of variables relating to technical and competitive aspects. Specifically, where the number of networks competing in the market is highest we observe longer exclusivity periods. Longer periods of exclusivity are also associated with market concentration and competing standards.*

Of these results the most striking is number two. This questions the prevailing assumption of duration of exclusive distribution as some function of the original exclusivity.

The significance of market-specific variables is strongest when examining the duration of exclusivity. In this case there was evidence that switching costs - proxied by competing standards - result in longer exclusivity which is a natural result when considering customer inertia in switching providers. Similarly the variables concerning competition and market inequalities both suggest the use of the iPhone as a competitive lever, and also support the predictions of the literature concerning adverse selection in advertising. The remaining results are generally insignificant and subject to interpretation.

In conclusion, this paper has empirically demonstrated the existence of multiple processes in the imposition of exclusivity restraints. This result highlights the scarcity of the literature which examines optimal duration of vertical restraints and represents a springboard to further research in the area.

The Impact of Service Bundling on Consumer Switching Behaviour: Empirical Evidence from UK Communication Markets

Introduction

One of the key outcomes from the continuing advances in communication technology is the propensity for households and individuals to subscribe to an increasing range of communication services. These can include broadband internet, subscription-based television services (pay-TV), or landline telephones. Greater deregulation of communications markets, coupled with the increased convergence in technologies, have led to individual companies to provide greater numbers of these services. One of the emergent strategies employed by large UK providers of household communications is to offer subscribers a 'bundle' of services, often a discount on the equivalent combined selling price

Research by the both UK communications regulator Ofcom, and the FTC in the US, has suggested that households which subscribe to a bundle are less likely to switch provider for one or more of these bundled services. This is because such bundling creates 'switching costs' for consumers. Where switching costs exist consumers can become locked-in to the choices they make, which subsequently 'hinders customers from changing suppliers in response to changes in efficiency' [Farrell and Klemperer, 2007].

This part of the thesis empirically analyses consumer switching data to investigate whether bundling of services is used by integrated communication firms to create switching costs. It analyses a survey-elicited dataset of 2,871 households' subscriptions to communications services, whether they bundle their products, and their switching behaviour. The services which are covered by the study are those above (broadband, pay-TV, and landline) in addition to mobile telephone services. While there exists a large volume of literature examining switching behaviour amongst consumers, there is very little that explores the link between product-bundling and consumers' switching decisions. This thesis significantly adds to this slim empirical literature and builds on the literature on switching costs by including supplier identities and duration of subscriptions to services - variables rarely included.

The remainder of this paper offers a description of bundling and switching strategies and the policy context, followed by a review of relevant literature. There is an overview of the UK communications market which provides context to the investigation. Finally, a third chapter outlines the econometric methodology, data, and results. A discussion on the significance of the results concludes.

4. Switching, Bundling, and Policy

Large communication firms in the UK are increasingly offering customers bundles of services. This means that, where individuals previously subscribed to a number of services with different providers, there is a trend to purchase multiple services from a single provider. The present investigation investigates both how bundling of services affects the decisions of individuals to change provider in the context of switching costs, and also the effect this bundling has on the competitive environment.

4.1. Switching and Bundling

This section briefly introduces the concepts of switching costs and bundling, and also outlines the policy approach of regulators and competition authorities - illustrated by some high profile cases. A more formal review of the theoretical and empirical literature follows in the next section.

4.1.1. Bundling

Product (or service) bundling is one of a series of practices employed by firms which facilitates the sale of a number of goods to a single customer. Bundling is defined by Stremersch and Tellis [2002] as the sale of two products together, where there also exists separate markets for each. This is distinct from other similar practices such as Tying of products which makes the purchase of one good *contingent* on another. It is also distinct from the extreme example of 'full line forcing' which requires customers to purchase an entire range of products - this is more prevalent in intermediate goods markets.

Common examples where products are bundled includes the sale of shampoo and conditioner as a set, selling a toothbrush with the toothpaste, or the current case of communication services. In all cases there are distinct markets for the component prod-

ucts.

Bundling is a practice which is solely employed by firms and does not occur naturally in nature. It can be used as a competitive tool to assert dominance in one or more markets, or otherwise it can be used to incentivise consumers to alter their purchasing habits.

4.1.2. Switching Costs

Consumers face switching costs when they change supplier for a product or service. Switching costs occur because, prior to consumption of a good, a consumer must expend resources in addition to the purchase price. This can be in terms of learning how to use a computer program, research a new brand, or finding a new supplier. In this sense Valletti [2000] defines them as 'resources, in addition to the purchase price, spent to consume the product when such resources cannot be recovered if the consumer changes supplier'; these additional costs are sunk.

They are particularly prevalent where the relationship between consumer and supplier is characterised by frequent interactions such as repeat purchases. They also occur when the nature of a relationship is long-term such as in fixed-term subscriptions - relevant to the current case. Klemperer [1995] describes the sunk costs inherent in the consumer-supplier relationship as sufficient to cause 'ex-ante homogeneous products to become, after the purchase of any one of them, ex-post heterogeneous'.

Unlike bundling of products, switching costs can occur naturally. Individuals form psychological attachments to particular brands, or otherwise in many products there is an inevitable and unavoidable learning process which requires sunk effort from the consumer. They can, however, be exaggerated or created by firms in order to restrict consumer switching; these theories are outlined fully in the next section.

4.1.3. The Policy Approach to Bundling and Switching

In both the US (under the Sherman Act, 1890) and Europe (under Article 102 of the TFEU) bundling and tying practices are treated under a rule-of-reason approach. In both cases it must be shown that the tying conditions were an abuse of a dominant position by a firm. In both jurisdictions there have been a number of high-profile

cases brought against firms which have been seen to be leveraging monopoly power to foreclose associated markets. In the US in the case of Eastman Kodak v. Image Technical Services, inc[26] it was found that Kodak were abusing their dominant position in photocopiers to foreclose competition in aftersales services. In the EU in the cases of Microsoft[27] and TetraPak[28] it was found that the defendants were abusing their dominant position in the supply of, respectively, bundled media players software, and the tied purchase of cartons for TetraPak machines.

Regulatory concern over switching is mainly focussed in the area of consumer protection. There have been recent moves by a number of UK sector regulators to champion policies which would facilitate consumer switching including the endorsement of price comparison websites, production of helpsheets, and introduction of policies to streamline processes. In recent years, typified by Ofcom [2008], there has been greater scrutiny of the role of bundling in switching costs, though there is still a shortage of meaningful analysis. The activities of Ofcom in relation to switching and bundling are outlined in discussion of survey data in the next section.

The following section focusses further on the theoretical and empirical literature concerning bundling and switching costs.

[26] Case S54 U.S. 451
[27] Case T-201/04 Microsoft v Commission
[28] 92/163/EEC

4.2. Existing Research

This part of the thesis concerns bundling and switching, thus this review of the existing literature focusses on three areas: that surrounding switching and search costs; that which examines the motivation of the firm to engage in product bundling; and thirdly the empirical literature investigating drivers of consumer switching behaviour. One outcome of this review is that there exists a paucity of studies that explicitly explore the link between the bundling of products and its impact on consumer switching behaviour.

4.2.1. Switching and Search Cost Literature

Switching costs are a field of interest for regulators and economists since they represent a friction in an otherwise competitive environment. They restrict the changing of supplier when otherwise, absent switching costs, a buyer would switch as a result of unexpected changes in price or quality.

Farrell and Klemperer [2007] offer a broad overview of the major assertions in the field of switching and search costs and also offer some brief intuition into the role of bundling in switching costs. The authors define switching costs as existing where a buyer makes a purchase repeatedly and will find it costly to switch from one supplier to another - where consumers can become 'locked' into the purchase of a series of products - an effective long-term contract governed by a series of shorter term agreements.

This repeat-purchase element is particularly relevant in the study of service bundling where, as per Prince and Greenstein [2011], subscription to services implies a 'relationship' between provider and consumer - a service subscription is rarely a one-off purchase. With sufficient economies of scope in production, consumers can become locked into purchasing bundles of goods from a single supplier since price savings which are common with bundles can offset the sense that a consumer is 'locked in'.

Of further relevance, Klemperer [1984, 1987] observes that switching costs are often created or exaggerated by firms. These can include charges for the termination of a contract or set up charges at a new provider, repeat purchase discounts, or loyalty cards where the switching consumer forgoes their accrued benefits. The motivation for this behaviour is that switching costs makes consumers less price sensitive [Klemperer, 1984]. This leads to overall higher prices because consumers are less able to switch away

in response to negative changes in terms. The creation of switching costs are studied in several relevant case-studies in the study of mobile telecommunications - where there exist numerous different sources of barriers to switching. Xavier and Ypsilanti [2008] (in the UK), and Baker [2007] (in the US), identify issues of early exit charges, a cumbersome administrative burden in switching, changing of telephone number or email, technical incompatibility, or forced return of existing equipment - all of which create switching costs.

Switching costs can also have a dynamic impact which results in cyclical behaviour by firms. Both Klemperer [1984] and Chen [1997b] observe that the presence of switching costs can have the effect that firms alternate between a bargain then ripoff strategy in order to attract and subsequently exploit customers. Farrell and Shapiro [1988] also examine dynamic competition though in an overlapping generations setting. Where there is a turnover of customers (some 'die' and some are 'born') the authors find that incumbents have an incentive to exploit their 'tied' customer base rather than compete for newly born customers. With sufficient economies of scale in production the incumbent may also attempt to serve new customers resulting in the exclusion of new entrants to the market. The effectiveness of multi-period strategies is heavily contingent on whether consumers have foresight - meaning they predict rip-off pricing in some second period and are less attracted by low first-period prices. The effectiveness of multi-period strategies is also dependent on whether firms are able to distinguish between existing and new customers since this allows them to exercise price discrimination over the two different groups.

The notion of bargain-ripoff pricing is reinterpreted in Cabral [2008] as a decision made by a firm which must balance the two effects of 'investment' to attract new customers, and 'harvesting' to take advantage of existing customers which must pay to switch away. In this generalised setting the author finds that at small levels switching costs reduce overall price levels, but at higher levels they lead to overall higher prices.

Related to switching costs is the issue of search or 'shopping' costs. Farrell and Klemperer [2007] observe that shopping costs can cause individuals to make sub-optimal product choices. Examples of this include deliberate price complexity, or product proliferation where consumers must exert excessive effort in order to identify market information - even regarding their own usage [Miravete, 2009; Narayanan et al., 2007]. Pricing obfuscation which may distort the perceptions of consumers' likely benefit from

switching is also addressed by Valletti and Cave [1998] in their review of the UK mobile communications industry. There are also more benign sources of shopping cost such as cognitive shortcomings which are common in markets where the product is intrinsically complex. These can be resolved through appropriate policies such as mandating the way information is presented, or encouraging price-comparison services as mentioned in the previous section.

Introducing the notion of bundling to the switching literature, Klemperer [1992] suggests that the presence of shopping costs mean multi-product firms can soften competition through mutual carrying of identical product lines. In the author's model, where consumers seek to purchase all varieties of goods, but face a cost to travel between different vendors, firms can offer all products and extract as surplus some of the cost the consumer would otherwise have faced in travelling between vendors. This interface between bundling and switching forms one of the primary motivations of the present paper since in this instance it is firm's mutual benefit to bundle products.

4.2.2. Bundling Literature

A bundle of products is described by Stremersch and Tellis [2002] as being two (or more) separate goods being sold in a single package from a single supplier. The term 'separate' implies that there exists separate markets for the standalone products and thus that some consumers may wish (and are able) to buy the goods separately.

The authors also define two types of bundling. Price bundling involves the selling of two goods at a discount to their separate selling prices. Product bundling is where the functionality of the products may improve as a result of the bundling and thus consumer valuations of the bundle may be higher than the sum of the separate valuations, even where the bundle is not offered at a discount.

From a service-specific approach Ofcom [2008] (discussed later, in relation to empirical findings) observes that consumers place value on the ease associated with taking a bundle of goods from one manufacturer; this may be in terms of a unified bill in the case of home communication services, or otherwise through guaranteed interoperability associated with software bundles such as Microsoft Office.

Further to the bundle definition of Stremersch and Tellis [2002], though there may exist separate markets for constituent products in the bundle this is not a guarantee that all firms will choose to offer them individually. Indeed, firms can offer 'pure' or 'mixed' bundling. Pure bundling is where a firm chooses to solely offer goods as a bundle. Mixed bundling is where firms also sell the constituent products separately. Issues of pure- versus mixed-bundling represent a strategy choice on the part of suppliers. If all firms choose to only offer pure bundling then the Stremersch and Tellis [2002] definition is violated because for several goods to be classed as a bundle they must be available separately. An example of this is a pair of shoes which is considered a single item despite their being two objects - because there does not exist a separate market for left shoes (nor right). The distinction between pure and mixed bundling dictates many outcomes in the literature concerning the competitive effects of bundling [Chen, 1997a; Thanassoulis, 2011].

Although bundling can be used as a means of price discrimination in order to extract more consumer surplus than otherwise selling separate products by incentivising consumption of multiple goods, the main competitive theories relate to the use of bundling to extend market power. This can be achieved by preventing entry by a rival, or increasing the competitiveness of a bundling firm in one or more markets. Bundling can also be used as a means to soften price competition by differentiating suppliers as per Klemperer [1992]. The two separate themes - price discrimination and exclusion - differ in the impact of the correlation of consumer valuations for the products. Price discrimination to extract consumer surplus is most effective with negative correlation[Belleflamme and Peitz, 2010], whereas exclusion is most effective with positive correlation [Nalebuff, 2004].

Of particular relevance to the current investigation of multi-product suppliers of communication products are both Nalebuff [2004] and Whinston [1990]. Both authors illustrate how bundling can be used by a dominant firm in one market to foreclose another under a range of conditions. Nalebuff demonstrates that where consumer valuations are correlated a bundling incumbent can potentially price at such a level that it earns a higher profit than it would do in the case that if were a monopolist in two separate-selling markets. The application of this rationale to the present case is logical, since there are a number of firms in the sample which dominate their primary market (pay-TV in the case of Sky) which are offering bundled goods in secondary markets.

Continuing the theme of bundling as a tool of exclusion, Bakos and Brynjolsson [2000] in their theoretical analysis of the economics of aggregation also find an effect whereby bundling of large numbers of services (such as aggregation of internet content) can lead to exclusion of standalone suppliers. This results in a best response to a competitor bundling being retaliatory bundling.

A similar 'head-to-head' result is also reported in Klemperer [1992] which introduces demand for multiple products. The author finds that where consumers have inelastic demand for products, but face travel costs to purchase from more than one supplier, firms which non-cooperatively offering identical product lines can yield higher industry profits than the case where firms offer differentiated product lines - this results in softened, rather than intensified, competition.

Both Chen [1997a] and Thanassoulis [2011] find the opposite result to the above where the best-response to a pure-bundling rival is to remain a single-product firm owing to the increased competitive environment stemming from head-to-head competition. In the case of Chen [1997a] this result derives from a product differentiation effect but relies on one market (A) being a duopoly with uniform valuation for the product, and the second market (B) being competitive with non-uniform valuations. This result dominates the case where one firm chooses to adopt a mixed-bundling strategy. The Thanassoulis [2011] result stems from discrimination between two types of consumers, those which demand a whole bundle, and those which demand only individual components; this author predicts that the intense competition following the full-convergence (retaliatory bundling) outcome prompts some firms to remain as single-product providers.

The above literature relating to bundling presents two avenues for investigation: the relationship between bundling and switching; and the relationship between firms which offer products as a bundle and those that offer standalone services.

A section of the literature focusses on the use of bundles as a means to reduce search costs and facilitate customer acquisition by encouraging consumers to single-home their purchases [Bakos and Brynjolsson, 2000]. This literature does not, however, extend to the dynamic setting characterised by Klemperer [1984] and Chen [1997b] with respect to the switching literature. This present paper aims to offer evidence that would support either a notion that bundling either increases switching costs or otherwise that it facilitates switching.

Secondly, the literature concerning bundling indicates divergent predictions concerning the best response to a bundling rival dependent upon the degree of competition and also the structure of consumer valuations. The present investigation tests these predictions by examining the likelihood of switching provider when purchasing bundled services from integrated providers relative to those individuals who subscribe to standalone service providers.

4.2.3. Empirical Studies of Bundling and Switching

There have been several notable empirical investigations into switching costs - both in terms of quantification and determinants, and also relating to the market outcomes in the presence of switching costs. The findings of studies into switching are examined, since they have informed the process which elicited our data, before examining in more depth the few empirical studies of the impact of bundling on switching.

Although this present study utilises survey data, the existing empirical literature also examines observed real-world data, and there is a limited literature which utilises experimental data.

Observed Data

Pomp et al. [2005] offer a review of empirical investigations utilising a range of observational data, examining both switching costs and consumer switching behaviour. The studies encompass both the quantification of switching costs and also the factors which influence consumer switching behaviour. Although the various findings regarding the level of switching costs is informative, it is the latter which most informs this study. The authors highlight a range of findings from across the literature - they divide it into the effects on switching of both product- or firm-specific characteristics, and also individual-specific characteristics.

Universal across the literature reviewed by the Pomp et al. [2005] is the pervasion of the analysis of demographic variables; these studies inform the inclusion of various variables in this present study. Featured in the review, Hausman and Sidak [2004] examines subscription to long-distance calling plans and finds a positive relationship

between price sensitivity and both income and education (where price sensitivity leads to switching to lower-priced calling plans).

Royalty and Solomon [1999] in their study of price elasticities in choice of healthcare plan find decreased price sensitivity is associated with increased age and wealth. The relationship between age and switching is interesting since the age of respondents determines the type of market in which these individuals are used to operating. In terms of subscriptions to utilities such as telecom, older individuals may have experience of purchasing from state monopolist provider, in which case the culture of switching provider may present greater cognitive barriers than for younger people (for whom switching of provider is more commonplace).

Pomp et al. [2005] also discuss firm-specific variables which affect individuals' willingness to change provider. The significance of these determinants is particularly relevant as it implies that firm behaviour can mediate consumer switching behaviour. Both Chen and Hitt [2002] in their study of online investment brokers, and Carlsson and Löfgren [2004] (concerning airline choices), identify that perceived quality of an individual's own supplier increases the cost of switching. Of specific interest is the finding by Chen and Hitt [2002] that their variable 'resources' - a proxy for the breadth of services offered by a firm - is negatively correlated with switching and a positively correlated with customer acquisition. This indicates that the increased number of services offered by a single supplier both inhibits switching away and also attracts individuals from other suppliers.

Finally, Ranganathan et al. [2006] explicitly discusses the role of bundling in a mobile telecommunications environment. The authors utilise a dataset of 30,590 North American mobile subscribers who reach the end of their fixed-contract period with their current supplier and find that those individuals which make more 'relational investments' with their provider are less likely to switch. The investments include the duration of the subscription, the level of usage, and whether the user bundles services - where 'services' in this instance represents 'soft' services such as the inclusion of voicemail or browsing services with the standard voice-minutes and SMS messages contract. In this study these bundled add-ons services reduce the likelihood of switching.

Survey Data

An advantage with survey data is that it can elicit consumers' expectations, beliefs, and information that would otherwise be unknown by examining only their behaviour and revealed preferences.

The role of potential monetary savings cannot be underestimated in examining consumers' switching decisions; Wilson and Waddams Price [2010] find that 77% and 86% of respondents in the two surveys used in their study cite pecuniary motivations as a major incentive for switching. Giulietti et al. [2005] examines retail gas markets and also finds monetary savings to be significant, especially where there is little expectation that the individual's incumbent supplier will match the lower price.

Waddams Price and Webster [2011] examine switching across multiple markets including landline telephone and mobile telephone and also find a significant relationship between expected saving and switching. Though there are significantly different expectations concerning the rate of switching across these different sectors. The authors also investigate demographic variables and (unlike Royalty and Solomon [1999]) find a non-linear 'U-shaped' relationship between age and switching. This suggests that the oldest individuals are actually more likely to switch and so too are the youngest. The authors suggest that this may have its basis in the degree of spare time available to older (retired people). The authors also find a positive relationship between switching and education in concurrence with previous papers.

Waddams Price and Webster [2011] also assert that factors which alter the opportunity cost of search time will alter the propensity of individuals to search and switch. Specifically the authors suggest that higher income level of respondents would create a disincentive to search since income level is a proxy for the value of an individual's time. The authors instead find income is an insignificant determinant of switching behaviour, and only mildly positively significant in the case of searching. The opportunity cost rationale was also used to explain the education result (above), since higher levels of education could either reduce the time spent searching, or reduce the 'onerous' nature of searching. The opportunity cost rationale is utilised in this present study to include other household factors which limit (and stifle supply) of time available for switching, increasing its opportunity cost; this is discussed in relation to the results in section 6.3.

Examining previous studies in home communications products, the US Federal Communications Commission (FCC) conducted survey research in 2010 examining consumer switching behaviour. Amongst the findings the FCC found that the main stated reasons for broadband switching were either to switch to a superior service or alternatively a cheaper service (49% and 47%). Only 28% stated that poor service from their existing supplier was the reason for an eventual switch. Of particular importance and relevance for the subsequent analyses is that 44% of those who had switched a service (without moving house) stated a major reason as 'getting a bundle of services from a single supplier'. Moreover, of those that hadn't switched, 39% stated that having to change a bundle of services was a major reason for this. This indicates a preference for bundling from some consumers and matches the Ofcom [2008] findings that consumers value bundles per se, and have an aversion to unbundling once subscribed.

The UK communications regulator Ofcom has been active in examining bundling as an extension of its existing policy focus of enabling and empowering consumer switching. The regulator states: '... competitive communications markets are more likely to work well for consumers when it is quick and easy to switch between providers' [Ofcom, 2008]. The regulator carried out a series of interviews in 2008 designed to elicit individuals' views on bundled products, this study consisted of initial screening interviews, followed by interviews with individuals that had switched (or considered switching) services recently.

Investigating the differing effects of various configurations of bundled services, there were different attitudes to bundles with 'triple-play'[29] subscribers placing high value on the convenience of the bundle. This was not only in terms of an unwillingness to switch away from the supplier, but also in terms of their unwillingness to unbundle the services. Those individuals which bundled broadband with a fixed landline still stated a preference to remain bundled, but were more inclined to switch supplier. Those individuals which subscribed to a bundle containing pay-TV were least likely to switch or unbundle - owing to the complexity of changing pay-TV supplier. Of those which had attempted to switch, many reported obstructive behaviour from their existing supplier. It was found that those with lower education were less likely to successfully switch owing to the complexity of the switching process - confirming the findings of previous research. The study further found that those who worked full-time stated an unwillingness to switch due to the need to take time off work in order to be at home for engineer

[29]Triple-play is the term used to describe the bundle of landline, pay-TV, and home broadband.

visits relating to the switch of supplier.

Ofcom [2008] also found an unwillingness from consumers to switch supplier if a they had been with their existing supplier for a long time. Specifically, it was stated that customers felt some degree of loyalty to existing suppliers where a long-term relationship existed[30].

Prince and Greenstein [2011] is one of very few papers which empirically analyses the role of bundling in consumers' switching decisions by utilising a survey-elicited panel[31] approach to examine persistence of subscription to services and particular providers. The authors find similar results to earlier literature such as Chen and Hitt [2002] in that when individuals bundle services they are less likely to discontinue their use of that service (lower attrition rates). Specifically, for those services with declining rates of subscription (pay-TV and landline in this case), the decline was less marked amongst those subscribers which bundled the services with home broadband. A key result is that the authors estimate that suppliers earned in the region of $259 million per annum as a result of lower attrition of customers services - an amount which would have been lost without bundling.

Experimental Evidence

Although there is limited experimental literature concerning bundling or switching, Harris and Blair [2006] provides evidence that individuals bundle products to minimise search costs (in accordance with much of the theoretical literature). The authors found that, when presenting participants with a catalogue of audio Hi-Fi components, early advertising of bundles significantly increased the likelihood that the bundle was chosen - thus avoiding further search for separate components. The evidence for effort minimisation (as opposed to primacy effects) was supported through further interviews with participants.

[30] Ofcom [2008], p. 11.

[31] The authors actually use a pseudo-panel constructed using three demographically-similar annual surveys.

4.2.4. Contribution

This paper makes a substantial contribution to the understanding of the role of bundling practices and their effect on consumer switching of provider. It is the first paper to empirically test the role of service bundling on the likelihood of switching across a range of contested UK communication markets. It does this while also controlling for heterogeneity amongst the different suppliers and a range of different demographic variables which have been shown to be significant in previous studies.

To the best of the author's knowledge the only other papers which have empirically approached the role of bundling in consumers' switching decisions are Prince and Greenstein [2011] and Ranganathan et al. [2006]. Both of these find that bundling of services with a single provider significantly reduces the likelihood of switching provider. It is against these papers that the results of the current paper are most accurately measured - testing the broad hypotheses that bundling of products reduces the likelihood of switching provider for those products.

Beyond the issue of bundling, this paper presents an important test of the prevailing literature's assertions concerning demographic determinants of switching. It does so by comparing the performance of demographic-based models against models concerned with variables relating to the service to which an individual subscribes. The strength of the results indicates the importance of supplier and service specific variables and illustrates the flawed nature of attempts to evaluate the determinants of switching using demographic variables alone under the implicit assumption of homogeneous providers.

Notwithstanding, because the empirical literature offers significant and robust evidence that demographic factors can be a key determinant of the likelihood of an individual to switch supplier, this paper controls for these elements. The results show that although demographic variables alone are inaccurate predictors of switching behaviour, controlling for individual-specific characteristics in a broader model delivers stronger results than models featuring demographic or service-specific variables alone.

The paper concludes by empirically examining the scope for smaller single-product providers to compete with larger multi-product firms. This has not previously been addressed in the empirical literature and tests the theoretical hypotheses of Chen [1997a] and Thanassoulis [2011] versus those of Bakos and Brynjolsson [2000] and Klemperer

[1992].

5. The UK Communications Market

In examining firms' bundling strategies and resultant consumer switching behaviour, this part of the thesis focusses on the UK markets for household communications services. The study utilises a survey-elicited dataset of 2,871 households designed to examine household subscriptions to, satisfaction with, and switching behaviour surrounding, four common household communication services: subscription-based television (pay-TV); fixed-line broadband; mobile telephone; and landline telephone.

The following sections feature an introduction to the survey and an overview of the variables which are included in the dataset used in the investigation. Specific attention is paid to the household communication services featured in the study, and the main firms and their respective strategies with respect to the bundling of products. Finally, there is an overview of the remaining variables featured in the later econometric modelling including demographic variables.

5.1. The Survey

The survey used in this part of the thesis was commissioned by Ofcom and carried out by research firm Saville Rossiter-Base in March 2010 where the participants were chosen as the key decision makers in a household. The sample was selected in order to be geographically representative of the UK, with a second round of interviews carried out to ensure that minimum quotas were reached for the experimental variables. The majority of the data (2,008 individuals) was gathered through face-to-face interviews in the first round, while a second round of interviews took place online (863 individuals). The results of the survey, with a large selection of summary statistics, are detailed in Saville-Rossiter-Base [2010].

The survey was divided into several parts:

In the first part of the survey respondents were asked to which services their household subscribed and whether they bundle any of these services by subscribing to more than one through a single provider (and receive a single bill). They were also asked their general level of satisfaction with their current provider. In this first part respondents were also asked whether they had either switched services from one provider to another in the preceding twelve months, or considered switching but ultimately not switched; these were mutually exclusive options.

In the second and third parts of the survey respondents were asked to report their experiences and motivations surrounding, respectively, their switching and 'considering' behaviour. Two latter parts concerned demographic variables, and also some questions regarding involuntary switching (where the provider has been changed without the consent of the individual involved).

The survey itself consisted of up to 140 questions (mainly closed-form multiple choice) of which 36 were asked in the first part, with 43 and 37 questions in the second and third. Because this study is concerned with switching, those individuals which considered switching provider but ultimately didn't are classed as 'non-switchers'.

The dataset used in the current analysis is constructed using parts one and two of the survey and examines current provider for those services which have not been switched, and the provider at point of switching for those that were switched. From the initial sample of 2,871 individuals, 950 switched at least one service, while 23 households switched all four services in the twelve months preceding the survey. The distribution of switching between individuals is shown below in table 5.1.

Table 5.1.: Number of Services Switched by Household

Number of Services Switched	Frequency	Proportion
0	1,921	67%
1	565	20%
2	265	9%
3	97	3%
4	23	1%
Total	2,871	100%

5.1.1. Dataset Creation

The particular design of the survey led to several key considerations in the construction of the dataset which influenced those variables and individuals which are included in the dataset.

The choice of variables was constrained by inconsistencies in questions asked concerning their current provider and, if applicable, their provider at time of switching.[32] The variables missing from the information on previous provider includes price information, information concerning a discount for subscribing to a service, and measures of service quality. While explicit variables concerning these issues would have been desirable since they are present and significant in much of the previous literature, it is likely that service-specific metrics such as price are fairly uniform across firms, or otherwise (in the case of service-specific quality) correlated with the supplier of the service.

Although the UK can be considered to be a national market for all services (as opposed to smaller regional sub-markets) there do exist some geographical limitations to the provision of some services by specific providers, specifically in rural areas. A small number of the observed switches in the survey occurred because an individual has moved house and the individual's initial provider for a service was not available at the new address. Because these services have been involuntarily switched[33] they are excluded from the analysis.

[32] In section two respondents were asked a different set of questions to those in section one.

[33] These switches are involuntary because the subscriber may have wished to remain with their previous provider.

Time constraints in carrying out the survey also led to the non-collection of some data for those individuals which have switched many services. For these individuals, the excluded services were determined by a process of prioritisation, as per table 5.2.

Table 5.2.: Survey Priorities

Priority	Action
1	Switched Bundle
2	Switched Pay-TV
3	Switched Broadband
4	Switched Mobile Phone
5	Switched Landline

The above factors result in the total number of 2,871 respondents being reduced to a workable sample of 2,856 while the loss of observations across the separate services are shown in table 5.3. The term 'Service history' implies that the switched service was of sufficiently high priority to provide data on the previous supplier, and 'Movers without choice' illustrates those individuals which moved house and were unable to keep their existing supplier.

Table 5.3.: Sample Selection

	Pay-TV	Broadband	Mobile	Landline	Total
Subscribers	1,721	2,052	2,630	2,508	8,911
Non-switchers (a)	1,536	1,550	2,222	2,125	7,433
Switched	185	502	408	383	1,478
Service history (b)	154	489	340	334	1,317
Movers without choice (c)	25	48	11	38	122
Total included (a+b-c)	1,665	1,991	2,551	2,421	8,628
Loss of observations	56	61	79	87	283

Table 5.3 indicates the number of total subscribers for each of the service lines where

an individual may have up to four separate subscriptions and therefore data points regarding switching within the dataset. Because the excluded individual-service data points all concerned incidents of switching their exclusion is, on estimation, likely to bias the baseline likelihood of switching downward, if this is the case then this will be reflected in a more negative constant. Furthermore, the exclusion of observations based upon the prioritisation of services employed during data collection could lead to concern that the excluded observations are correlated with particular services; a simple probit analysis of instances of excluded observations against service-type indicates that this is not the case.

5.1.2. Variable Selection

The variables used in the econometric analysis are split into two categories; service-specific variables which vary between each service to which an individual subscribes, and individual-specific demographic variables which are uniform across an individual's subscriptions. Service-specific variables are focussed on the types of service to which a household subscribes, the firms which provide (or previously provided) those services, whether a household bundles multiple services with a single provider, and whether the household has switched provider for the service. Demographic variables reflect the properties of either the household (such as the number of children), or otherwise the characteristics of the key decision maker in the household (such as education).

Almost all the variables included in the study dataset are of a categorical nature and as such are represented by a series of dummy variables where the significance of a particular category will be measured relative to a base category, and where the base category for each variable is chosen such that it is an *informative* category[34] which is excluded.

Because of the large number of variables employed in the final analyses, where the data is fully laid out in the subsequent sections, each table clearly indicates the symbols used to represent the coefficient pertaining to each variable in the econometric specifications of section 6.2 (page 141).

[34] An example of an informative category within the DURATION variable would be '7 to 12 months' as opposed to 'Don't know' since it is difficult to determine the significance of duration categories relative to 'Don't know'.

5.2. Household Communication Services

This study concerns the four UK household communication services featured in the 2010 Ofcom survey: subscription-based TV services (pay-TV); fixed-line broadband; mobile telephone; and landline telephone.

In the UK each of the services is available in many cases as a standalone product from a number of firms which operate on a national basis. The history of provision, mode of delivery, regulatory considerations, and geography have impacted on which firms choose (or are able) to offer specific services. The following sections introduce the respective services and offer an outline of the technological considerations facing providers, before the data relating to communication services is summarised in section 5.2.5.

5.2.1. Subscription-based Television

Subscription-based television, or pay-TV, is the term used to describe TV broadcast services to which people pay to subscribe. This is different to those television channels which are freely available (disregarding the annual television licence fee which must be paid in the UK). A pay-TV subscription can vary in price and size (as measured by number of channels), where premium content such as sports or films can be included in a subscription for an additional fee. The largest provider in the pay-TV market is Sky which is a vertically integrated firm which is involved in both the broadcasting by satellite, and production of, TV content. In the current dataset the broadcaster Sky has a share of around 66% of pay-TV subscriptions while the next largest operator is Virgin with a share of around 27%.

The technology required to deliver and receive pay-TV used to be limited to satellite or fibre-optic cable Changing technology and access regulation (Sky is required to allow other broadcasters to show some of its channels where it has exclusive content such as films or sport) have meant, however, that content can increasingly be broadcast by other means. Recent technological advancements have enabled other providers to enter this market by broadcasting premium content over fixed broadband (notably BT Vision). The mandated access to Sky's premium content (through the UK regulator Ofcom's wholesale must-offer obligation [Ofcom, 2012a]), coupled with the existing broadband infrastructure, have meant that the entry costs into this sector are currently

far lower than they have been historically when provision of Pay-TV was inextricably linked to the need to create a broadcasting TV-specific infrastructure.

5.2.2. Fixed-line Broadband

Fixed-line broadband is the term used to describe a broadband connection which is installed in the home and enables the user to access the internet or stream content such as music, films, or live TV. This service definition does not include that broadband which is delivered wirelessly; this service is typically offered by dedicated mobile phone service providers but is not included in our study.[35] Fixed-line broadband is generally delivered over a home landline connection (see section 5.2.4) and as such often requires the subscriber to subscribe to a landline (though this may not necessarily be provided by the same firm). The adoption of broadband by homes has increased rapidly in recent years; only 31% of homes in 2005 had broadband, while 74% of all homes had broadband access in 2011, of which 67% used a fixed-line delivery [Ofcom, 2011].

The regulatory environment surrounding broadband is similar to that governing landline telephony. Because it is delivered using a conventional landline, and this landline infrastructure in primarily owned by the ex-state-owned incumbent BT, the regulator Ofcom has implemented a regime of mandatory access. As a result, entry costs to this sector is low and, consequently, there are many firms which are able to offer broadband services.

5.2.3. Mobile Telephone

While chapter 2 of this thesis featured a detailed study of the characteristics of mobile telecommunications, the following paragraphs introduce specific information which is relevant to UK mobile telephony.

In defining mobile telephony the study includes those providers of, and subscribers to, voice and data communication utilising a mobile phone. Mobile telephony reached mass-adoption in the late-1990s and ownership of mobile phones exceeded the number of landlines in 2008 [Ofcom, 2011]. This is illustrated in table 5.5 where mobile subscriptions outnumber landline by 2,630 to 2,508. Technological considerations require

[35] This is likely related to the novelty of the service at the time of the survey (March 2010).

that firms must be licensed in order to operate a mobile phone network in the UK and these licences are issued by the communications regulator, Ofcom.

This spectrum bandwidth licensing (following the 2002 bandwidth auction) resulted in five licensed operators but this number was reduced to four in 2011 following the merger of two firms (the UK subsidiaries of France Telecom and Deutsche Telekom). In addition the UK regulator allows agreements between licensed operators and non-licensed firms to allows the latter to operate a mobile network across bandwidth 'owned' by the former.[36] The largest of these Mobile Virtual Network Operators (MVNOs) is operated by Virgin Media and has more subscribers in our sample than licensed operator Three Mobile; other notable MVNOs include Tesco, and Lebara - a specialist service offering calls abroad. Notably, MVNO access to licensed operator networks is not mandated [Ofcom, 2012b].

5.2.4. Landline Telephone

Landline telephone is the term used to describe the traditional telephone that was historically installed in houses or businesses. In the UK landline telephony was historically state-owned and operated by the incumbent British Telecom (BT) which is no longer under state control. In examining the current dataset the incumbency effect of BT is quite clear since, although privatisation of BT occurred in 1984, the firm still has a 50% share of landline subscribers (as per table 5.5). Deregulation of the sector since the privatisation of BT has sought to make entry into the sector easier. This has culminated in the current scenario where access by a competitor to BT's landline infrastructure is mandated and access-pricing heavily-regulated. The number of subscriptions to landline telephone has declined in recent years following the mass adoption of mobile telecommunications (and the technological improvement in the mobile sector which made it a viable alternative to a fixed telephone).

[36] Mobile telecom bandwidth must be rationed in a similar way to conventional household FM radio broadcasts where each station is allocated a specific range of frequency, without rationing radio stations (and mobile telecom networks) might try to broadcast on the same frequency resulting in interference and a breakdown of service

5.2.5. Service Indicator Variables

Because each dependent variable data point in the analysis pertains to a specific service, dummy variables are included to indicate which[37]. The dummy variables are intuitively titled **PayTV, Broadband, Mobile** and **Landline**. The service variables are included as standalone dummy variables but they are also included in an interacted form with variables concerning the supplier[38], the variable indicating that a service is bundled, and also a variable representing the number of services to which an individual subscribes through the supplier of their given service. Table 5.4, below, indicate the co-efficients which are relevant to the above standalone variables and also the interactions.

Table 5.4.: Service Variables

Service	Variable name	Standalone co-efficient	Number of subscribers	Interacted with: Supplier	Bundled	Duration
Pay-TV	TV	$\beta_{\text{TV},0}$	1,665	$\beta_{\text{TV},1} \rightarrow \beta_{\text{TV},6}$	$\beta_{\text{TV},7}$	$\beta_{\text{TV},8} \rightarrow \beta_{\text{TV},13}$
Broadband	BB	$\beta_{\text{BB},0}$	1,991	$\beta_{\text{BB},1} \rightarrow \beta_{\text{BB},6}$	$\beta_{\text{BB},7}$	$\beta_{\text{BB},8} \rightarrow \beta_{\text{BB},13}$
Mobile	Mob	$\beta_{\text{Mob},0}$	2,551	$\beta_{\text{Mob},1} \rightarrow \beta_{\text{Mob},6}$	$\beta_{\text{Mob},7}$	$\beta_{\text{Mob},8} \rightarrow \beta_{\text{Mob},13}$
Landline	LL	$\beta_{\text{LL},0}$	2,421	$\beta_{\text{LL},1} \rightarrow \beta_{\text{LL},6}$	$\beta_{\text{LL},7}$	$\beta_{\text{LL},8} \rightarrow \beta_{\text{LL},13}$

The expectation of the signs for the estimated coefficients are discussed in section 6.2.1.

5.3. Service Supplier

The 2010 Ofcom survey asked respondents to indicate which of 36 providers[39] they used for each of the household communication services to which they subscribed. The responses to the survey indicated that there are only a handful of large communication companies with significant market shares in one or more of the individual communication markets. In addition to these few firms there are a number of smaller operators that have emerged as a result of the regulatory intervention that has reduced barriers to

[37] This is identical to the 'market' variable used in Waddams Price and Webster [2011]

[38] Where multiple coefficients are listed as referring to supplier they always correspond, in ascending order, to the six suppliers BT, SKY, Talk-Talk, Virgin, Mobile, Others.

[39] There were 35 closed-form options in addition to an open 'Other Supplier' category.

entry. There is also a periphery of other firms to which very few respondents subscribed.

Table 5.5 shows the share of subscribers for each of the services as accounted for by the largest 15 firms.

Table 5.5.: Survey respondents subscriptions by service provider (March 2010)

	Pay-TV		Broadband		Mobile		Landline	
Firm	Subs	%	Subs	%	Subs	%	Subs	%
AOL	3	0.17	103	5.02	1	0.04	30	1.2
BT	68	3.95	487	23.73	19	0.72	1262	50.32
Kingston	0	0	10	0.49	0	0	15	0.6
O2	0	0	88	4.29	696	26.46	7	0.28
Orange	2	0.12	81	3.95	566	21.52	19	0.76
Pipex	0	0	19	0.93	0	0	11	0.44
PlusNet	1	0.06	44	2.14	0	0	8	0.32
Post Office	2	0.12	10	0.49	3	0.11	38	1.52
Sky	1140	66.24	255	12.43	5	0.19	199	7.93
Talk-Talk	7	0.41	254	12.38	13	0.49	288	11.48
'3' Mobile	1	0.06	7	0.34	168	6.39	0	0
Tiscali	3	0.17	76	3.7	2	0.08	35	1.4
T-Mobile	2	0.12	3	0.15	324	12.32	2	0.08
Virgin	458	26.61	508	24.76	176	6.69	493	19.66
Vodafone	2	0.12	3	0.15	503	19.13	3	0.12
Others	32	1.85	104	5.05	154	5.86	98	3.89
Total	**1721**		**2052**		**2630**		**2508**	

Table 5.5 shows that some firms have dominant positions in some markets. For instance, Sky has a particularly high market share in pay-TV whereas BT's landline market share is over 50% but their share of subscribers of pay-TV is much lower at 3.95%. The relative strengths of the firms can be understood as being the result of some inherent market advantage, or 'specific asset' that each firm possesses which gives the relevant firm a relative superiority in the provision of some services. The theory of specific assets[40] specifies that, where a firm possesses a specific asset, resources directed toward this activity have greater effectiveness they would for other firms, either

[40]Specific Assets are introduced in Williamson [1975] in the context of international trade and process internalisation versus market transactions.

through technological superiority, or otherwise intangible assets such as consumers' perception of brand identity. In the current case of UK communication markets these advantages in the provision of some services are largely the result of some historical firm significance. This may be the status of being an ex-nationalised incumbent (which creates an intangible psychological association between the firm and delivery of a particular service), or otherwise from being a technological pathfinder and investing early in fledgeling technology in the case of Sky leading to a tangible technological advantage. The relative strengths and historical context of the leading firms are discussed further in section 5.3.1.

Since this study is focussed on the impact of bundling on switching behaviour it is also relevant to examine the types of bundles to which households declared they subscribe through each firm. Table 5.6 shows all possible bundle combinations, based upon the four individual services, and the number of subscribers to each. Given the particular survey design, subscription to a bundle of services with one firm precluded subscription to another bundle with the same, or different, supplier (a household could only have one bundle). The definition of bundling here is based upon that used in the survey; where an individual receives multiple services from a single provider, and receives a single bill. Each service is represented by a letter (pay-TV = T, broadband = B, mobile telephone = M, landline = L) and thus, for example, the bundle TBL represents one containing pay-TV, broadband, and landline.

Table 5.6 indicates that, similarly to the case of particular services, different firms place different focus on product bundling. These differences are discussed in the following sections in addition to the outline of the relative strengths and specialities of the main providers. Also discussed, of specific interest to bundling, is the notion of core services which represent those services offered by firms in which they have a core competency and which often contribute to the bundling strategy of firms.

5.3.1. Major Suppliers

As stated, though the survey requested that individuals indicate which of 36 different suppliers they use for their service the evidence suggests that there is actually a small number of leading suppliers; consequently the analysis in the present study focusses on six different categories of provider. Each of the main four suppliers of multiple ser-

Table 5.6.: Number of survey respondents by bundle type (March 2010)

	Bundle Type											
Firm	ALL	TBM	TBL	TML	BML	TB	TM	TL	BM	BL	ML	**Total**
AOL	-	-	-	-	-	-	-	-	-	20	-	**20**
BT	1	-	33	1	4	1	-	6	-	**299**	-	**345**
Kingston	-	-	-	-	-	-	-	-	-	-	-	**0**
O2	-	-	-	-	-	-	-	-	9	1	-	**10**
Orange	-	-	-	-	7	-	-	-	6	7	1	**21**
Pipex	-	-	-	-	-	-	-	-	-	7	-	**7**
Plusnet	-	-	-	-	-	-	-	-	-	8	-	**8**
Post Office	-	-	-	-	-	-	-	-	-	8	-	**8**
Sky	2	-	**150**	1	-	84	-	24	-	1	-	**262**
Talk-Talk	-	-	6	-	3	-	-	-	-	**192**	-	**201**
Three Mobile	-	-	-	-	-	-	-	-	1	-	-	**1**
Tiscali	-	-	2	-	-	-	-	-	-	29	-	**31**
T-Mobile	-	-	-	-	-	-	-	-	-	1	1	**2**
Virgin Media	27	1	**308**	1	2	25	-	49	-	64	1	**478**
Vodafone	-	-	1	-	-	-	-	-	-	1	-	**2**
Others	-	-	1	-	3	-	1	-	1	22	-	**28**
Total	**30**	**1**	**501**	**3**	**19**	**110**	**1**	**79**	**17**	**660**	**3**	**1424**

vices is represented by their own category, being BT, Sky, Talk Talk, and Virgin. The mobile phone operators which table 5.5 shows to be focussed mainly on provision of mobile telecommunications (O2, Orange, T-Mobile, Three, Vodafone) are represented as a single category. Finally, there is a category which represents a subscription to any of the remaining firms. Each of these provider categories is outlined below.

British Telecom

British Telecom (BT) is the ex-nationalised incumbent landline operator which had a monopoly over telecommunications until 1984 (when deregulation of the sector began). The firm has an advantage in the provision of home landline services as a result of its ex-incumbency status; it owns the infrastructure that allows it to operate landline services as opposed to having to purchase access at regulated prices like its competitors (to whom it has an obligation to supply). As the ex-nationalised incumbent it also has the advantage of consumers' psychological association of the brand with the provision of landline services where its core business still remains and where it has over a 50% share of subscribers in the survey. BT also has a significant presence in the home broadband markets since many households, when adopting home broadband for the first time, chose to subscribe through their existing landline operator [Ofcom, 2011]. This is readily understood when considering that the two services are delivered through broadly similar means.[41] Many smaller firms which specialise in the provision of standalone broadband services also require their subscribers to subscribe to BT landline services - this stems from the technological aspects of broadband provision across the existing landline network infrastructure (primarily owned by BT).

The success of BT in leveraging its existing customer base is keenly illustrated since 345 survey respondents declared that they subscribe to bundled products through BT, moreover this number is dominated by the broadband-landline bundle (299). In total 336 of those respondents which bundled with BT had both broadband and landline as components in the bundle. Given that BT has 487 subscribers to its broadband service (table 5.5), this implies that 69% of these broadband subscribers subscribe to the service as part of a bundle.

BT is also one of the earliest firms to offer subscription-based TV services over broad-

[41] The role of delivery method of a bundle is discussed in Ofcom [2008].

band, again the majority of subscribers to these services do so as part of a bundle with BT's core landline service (42 out of 68).

Sky

Sky are the main provider of subscription-based TV services in the UK and account for 66% of the subscribers to pay-TV services in the survey. Sky's dominance is largely the result of the first-mover advantage they have maintained in the provision of subscription-based TV services and the firm's vertical integration into broadcast of high-profile premium content. Sky primarily deliver their pay-TV services via satellite broadcast[42] and are the only main operator to do so, requiring users to install a satellite dish at their property (which can potentially increase the costs of switching to or from Sky). The dominance of Sky in the pay-TV market has led the sector regulator to require that Sky allow rival providers to broadcast a selection of their premium channels, specifically sports and films at a regulated price.

Sky also offers landline and broadband services which are delivered via a conventional landline connection (owing to the access requirements placed on BT, owner of the landline network). Almost all subscribers to these services through Sky do so as part of a bundle with Sky's core TV service (236 out of 255 subscribers to Sky broadband, 176 out of 199 for landline). However, the majority of individuals in the survey who subscribe to Sky's core pay-TV service, do so as a standalone subscriber without bundling (86%).

Talk Talk

Talk Talk is a provider, demerged from UK cellphone retailer Carphone Warehouse in 2010, which specialises mainly in the provision of landline and home-broadband services. It has grown largely through acquisitions of smaller firms which emerged through the deregulation of landline, and also the growth of broadband services (Talk Talk acquired AOL's UK broadband service in 2007). This focus on these services is reflected in the survey response data where it has an 11-12% market share in both services (254 and 288 subscribers for broadband and landline respectively). Notably, most of the subscribers (around 80%) to these services through Talk Talk receive both as part of a

[42]Though technological advances now allow subscribers to stream content online.

broadband-landline bundle.

Talk Talk, unlike many of the other firms, does not have some technological core competency or infrastructure advantage. It has instead grown out of the change in the regulatory environment allowing increased competition in the UK landline sector (via which both of its main services are delivered).

Virgin Media

Virgin Media are an integrated communications firm with a significant share of around 20% of subscribers across pay-TV, broadband, and landline services. It is also the only firm specialising in these areas which has a notable presence in mobile telecommunications; this is despite the firm's lack of a formal mobile operator licence (see section 5.2.3). Virgin were the first firm to offer a truly integrated package at a time that the other suppliers were offering standalone services. The firm still primarily offers services as bundles with the incremental cost of adding additional services to the bundle generally lower than the equivalent standalone price for the service. Virgin Media is also different from its rival providers of broadband, or pay-TV, in that it delivers almost all content in these services via a fibre-optic cable. Like Sky's satellite delivery, installation of a fibre optic cable to the home represents a switching cost to subscribers. The use of fibre-optic provision allows faster broadband speeds (enabling faster downloads or display of web pages) than broadband provision via a conventional landline, giving Virgin a technological advantage over its rivals such as BT which have only recently (post-2010) begun investing in fibre-optic infrastructure.

Virgin Media does not have a clear core service, in the way the Sky have TV. While this may be related to the unique delivery method, it has the result that subscribers to Virgin services are very likely to bundle. This high bundling rate is persistent across pay-TV, broadband, and landline where 90%, 84%, and 92% of subscribers to the respective services do so as part of a bundle. These headline figures are particularly high compared to bundling rates for those firm-specific core services such as pay-TV through Sky, or landline through BT.

Mobile Operators

Mobile operators are categorised as those firms which possess a Wireless telegraphy Act Licence (WTA) which allots them a segment of the available bandwidth for broadcast of mobile telephone signals. This consists of Orange, O2, T-Mobile[43], Three Mobile, and Vodafone. Collectively these firms account for 2,257 out of 2,630 of respondents in the survey which subscribed to a mobile telephone service but much lower proportions for other services such as fixed broadband. This concentration of subscribers in the core service of the mobile firms is similar to Sky which has a unique method of delivery for its core service, with peripheral services delivered by different means.

Other Firms

The other firms featured in the survey are all small firms which tend to offer only one or two services and where landline or broadband services are heavily represented. Also included in the list of other firms are those small mobile phone MVNO operators such as Tesco, and other single-product focussed firms. The data suggests that generally subscribers to other firms are less likely to bundle, being that these firms account for around 4% of subscribers, but only 2% of bundles.

Given the lower likelihood of bundling through these smaller providers, it can be interpreted that many of these suppliers are single-product firms, and as such are focussed on a single 'core' service.

Provider Summary

Table 5.7 summarises the position of the main operators with respect to the main service delivery methods and their respective core and peripheral services. The core services represent those with which the firm is most clearly identified, and those firms that have multiple core services are known for their bundling of those services.

[43]Orange and T-Mobile have, subsequent to the survey, merged their UK operations.

Table 5.7.: Providers' core and peripheral services

	Infrastructure	Services	
Provider	Core-Competency	Core	Peripheral
BT	Landline Infrastructure	Landline	Broadband, TV
Sky	Satellite Transmission	Pay-TV	Landline, Broadband
Talk Talk	Landline Infrastructure	Landline, Broadband	-
Virgin	Fibre Optic Cable	Pay-TV, Broadband, Landline	Mobile
Mobile Operators	Wireless (3G) Networks	Mobile Telephone	Landline, Broadband
Others	-	Various	Various

5.3.2. Service Indicator Variables

In the econometric analysis, for each data point regarding switching, a dummy variable is used to indicate the relevant provider for the service. Table 5.8 indicates the variable names for each provider category and also the coefficients representing the standalone supplier variable and also those variables with which it is interacted. As per table 5.4 the relevant symbol for each variable is also shown. The frequency of subscription to each supplier in the final dataset (after the restrictions of table 5.3 were applied) is also displayed.

Table 5.8.: Provider Categories

Provider	Variable name	Standalone coefficient	Number of subscribers	Interacted with: Bundled	Interacted with: Duration
British Telecom	BT	$\beta_{\text{BT},14}$	1,895	$\beta_{\text{BT},15}$	$\beta_{\text{BT},16} \rightarrow \beta_{\text{BT},21}$
Sky	Sky	$\beta_{\text{Sky},14}$	1,530	$\beta_{\text{Sky},15}$	$\beta_{\text{Sky},16} \rightarrow \beta_{\text{Sky},21}$
Talk-Talk	Talk	$\beta_{\text{Talk},14}$	478	$\beta_{\text{Talk},15}$	$\beta_{\text{Talk},16} \rightarrow \beta_{\text{Talk},21}$
Virgin	Virg	$\beta_{\text{Virg},14}$	1,483	$\beta_{\text{Virg},15}$	$\beta_{\text{Virg},16} \rightarrow \beta_{\text{Virg},21}$
Mobile Firm	Mobfirm	$\beta_{\text{MobF},14}$	2,386	$\beta_{\text{MobF},15}$	$\beta_{\text{Mob},16} \rightarrow \beta_{\text{Mob},21}$
Other	Other	$\beta_{\text{Oth},14}$	856	$\beta_{\text{Oth},15}$	$\beta_{\text{Oth},16} \rightarrow \beta_{\text{Oth},21}$

5.4. Other Service-specific Variables

In addition to the type of services and providers to which households subscribe, respondents were asked (as per table 5.6) whether they bundled those services, and also the duration for which they have subscribed to the service through the stated supplier. This data is also included in the econometric investigation and is shown in tables 5.9 and 5.10.

5.4.1. Bundle Status

This binary variable is core to the investigation and is equal to 1 where the particular service is subscribed-to as part of a bundle of other services from a single supplier, otherwise it is zero. The significance of the estimated coefficient attached to the 'bundle' variable will indicate whether bundling of services has a significant effect on the likelihood of switching supplier, though this will be mediated by the significance of the

interaction variables containing the 'bundled' variable.

The prioritisation of the certain switching behaviour in the dataset may lead to a priori expectation that non-bundled products would be more likely to be excluded leading to bias in the dataset,robustness checks indicate that this is not the case.

Table 5.9.: Bundling by Service Type

Bundle status	Variable name	Coefficient	Bundlers by service type: Pay-TV	Broadband	Mobile	Landline	Interacted with: Duration
Yes=1	Bundled	β_{22}	628	1,126	55	1,094	$\beta_{23} \rightarrow \beta_{28}$
No=0	-	-	1,037	865	2,496	1,327	-

5.4.2. Duration

The duration of an individual's subscription to a service with a given supplier is included as discrete duration categories. In the results, a relatively smaller coefficients relating to longer duration categories would signify a negative relationship between duration of subscription and probability of switching. Relatively larger and positive coefficients attached to longer duration would indicate a positive relationship. Again, table 5.10 reports the respective coefficients for each category and also the frequency of the categories in the dataset by service type.

Table 5.10.: Duration of Subscription by Service Type

Duration	Variable name	Coefficient	Duration by service type: Pay-TV	Broadband	Mobile	Landline
6 months or under	DUR Sub-6m	β_{29}	102	109	85	123
7 to 12 months	DUR 6m-1yr	β_{30}	130	156	163	164
13 to 24 months	DUR 1yr-2yr	β_{31}	293	555	511	464
25 to 48 months	DUR 2yr-4yr	β_{32}	295	451	451	392
Over 48 months	DUR over-4yr	β_{33}	780	654	1,227	1,182
Don't know	DUR Don't know	β_{34}	65	66	114	91

5.5. Individual-specific Variables

There are a number of demographic variables which have been identified in the existing empirical switching literature as having a statistically significant impact on individuals' switching behaviour. Questions relating to demographic factors were also included in the 2010 Ofcom survey.

The collection of the data by Saville Rossiter-Base was carried out such that participants were chosen to be representative sample based upon three criteria: age; gender; and socio-economic group. Furthermore, the respondents were geographically distributed between sampling units based upon UK census Output Areas, ensuring that the demographic profile of the sample is representative of the UK population. Finally, the sample was selected such that a minimum quota of subscribers to each service was satisfied to allow meaningful analysis of the data.

Like the service-specific variables individual-specific demographic variables are categorical (owing to the closed-form of the questions) and thus included as series' of dummy variables. The following sections outline distribution of the variables included in this present analysis for the experimental sample.

5.5.1. Household Income

Household income is included as a series of income categories in the survey. A positive relationship between income and switching-likelihood would result in a larger estimated coeffiecient attached to those dummy variables for higher income categories, a negative relationship would result in larger coefficients attached to those dummies for lower income. The number of households in each of the income categories in the survey is shown in table 5.11.

Table 5.11.: Household Income Categories

Household income level	Variable name	Coefficient	Frequency
Under £11,500	INCOME sub-11500	γ_1	396
£11,500-£17,499	INCOME 11500-17499	γ_2	298
£17,500-£29,999	INCOME 17500-29999	γ_3	480
£30,000-£49,999	INCOME 30000-49999	γ_4	463
£50,000 and over	INCOME 50000+	γ_5	250
Don't know	INCOME Don't know	γ_6	269
Refused	INCOME Refused	γ_7	700

5.5.2. Children

The analysis contains a dummy variable equal to 1 if there are children in the household.

Table 5.12.: Children in Household

Children?	Variable name	Coefficient	Frequency
Yes=1	Children	γ_8	947
No=0	-	-	1,909

5.5.3. Employment Status

The employment status dummy variables represent the different options in the survey. If individuals who work full-time are (for example) less likely to switch relative to those that work part-time then it would be expected that the estimated coefficient relating to full-time employment (γ_9) would be more negative than that for the part-time dummy.

Table 5.13.: Employment status

Employment status	Variable name	Coeffiecient	Frequency
Full-time (30+ hours per week)	EMPLOY Full-time	γ_9	1,110
Part-time (under 30 hours per week)	EMPLOY Part-time	γ_{10}	412
Looking for work	EMPLOY Looking	γ_{11}	91
Full-time education	EMPLOY Education	γ_{12}	108
Retired	EMPLOY Retired	γ_{13}	690
Not working	EMPLOY Not	γ_{14}	430
Refused	EMPLOY Refused	γ_{15}	15

5.5.4. Gender

Gender is represented in the study by a dummy variable equal to 1 if the respondent is male; table 5.14 suggests that slightly more household decision makers were women:

Table 5.14.: Gender of Respondents

Gender	Variable name	Coefficient	Frequency
Female=0	-	-	1,474
Male=1	Gender	γ_{16}	1,382

5.5.5. Education

Respondents were asked at what age they finished (or expected to finish) full-time education according to discrete categories which were designed to roughly proxy the educational achievement level of the individual. Under-17 would be the lowest level of academic achievement (known as O-level or GCSE dependent upon the age of the respondent), 17-18 would represent additional academic achievement (A-level) or some basic vocational training, 19-20 may indicate more advanced vocational training, while aged over 21 would indicate a university qualification. If education and switching behaviour are positively correlated then it would be expected that those coefficients relating to a later education leaving age would be significant and more positive relative

to those for individuals who left education earlier.

Table 5.15.: Age at Finishing Education

Age left education	Variable name	Coefficient	Frequency
Aged under 17	EDU under-17	γ_{17}	1,152
Aged 17-18	EDU 17-18	γ_{18}	605
Aged 19-20	EDU 19-20	γ_{19}	249
Aged 21 and over	EDU 21+	γ_{20}	805
Don't know	EDU Don't know	γ_{21}	35
Refused	EDU Refused	γ_{22}	10

5.5.6. Age

In the survey data the age of respondents was recorded in discrete categories, these are shown in table 5.16, and the respondents were chosen in order to be a representative sample of the UK population.

Table 5.16.: Age of Respondents

Age	Variable name	Coefficient	Frequency
Aged under 18	AGE under-18	γ_{23}	35
Aged 18-24	AGE 18-24	γ_{24}	222
Aged 25-34	AGE 25-34	γ_{25}	562
Aged 35-44	AGE 35-44	γ_{26}	535
Aged 45-54	AGE 45-54	γ_{27}	491
Aged 55-64	AGE 55-64	γ_{28}	465
Aged 65-74	AGE 65-74	γ_{29}	383
Aged 75 and over	AGE 75+	γ_{30}	163

6. Investigating Bundling and Switching

This part of the thesis analyses the impact of the 'bundling' of communication services with a single supplier on the likelihood of an individual switching their subscription for a service to a different provider. It utilises a discrete-choice cross-sectional survey data of 2,871 individuals which responded to questions regarding their switching behaviour over the four services of interest: pay-TV; home broadband; mobile telephone; and landline telephone.

6.1. Econometric Methodology

Using survey data this study analyses an individual's decision to switch provider of an existing service as a binary choice determined by both the characteristics of the service such as the provider, and also determined by the measurable characteristics of the individual such as age or education level. The switching decision is similarly expressed to that in Waddams Price and Webster [2011] where a dummy variable is included to indicate the particular market in which the switch took place (pay TV, broadband, mobile phone, or landline).

The present study focusses primarily on those variables concerning the supplier at time of switching in order to capture the impact that the bundling of a service with other services from a single supplier has on the probability of switching that service. Specifically, by controlling for other supplier-specific variables which are likely to be influential, it is possible to isolate the pure effect that bundling at the time of switching has on the subsequent likelihood of switching.

From the findings in the previous literature in chapter 4.2.1 the propensity to switch provider is likely to be some function of a range of variables, such that:

$$\begin{aligned}\text{Switching propensity} = S\,(&\text{Service, Bundled, Duration, Supplier,}\\ &\text{Duration}\times\text{Supplier, Duration}\times\text{Service, Duration}\times\text{Bundled,}\\ &\text{Supplier}\times\text{Service, Supplier}\times\text{Bundled, Service}\times\text{Bundled,}\\ &\text{Income, Employment, Children, Education, Gender, Age)}\end{aligned}$$

Where 'Service' represents which of the four services in the study is under consideration, 'Bundled' concerns whether this service is part of a bundle,'Duration' represents the length of time that the individual has subscribed to the service, and 'Number of services' is the number of services to which the individual subscribes with the same supplier. The variables which are used to represent all these factors are described and summarised in section 5.1.

Chapter 5 of this thesis indicated that bundling strategies and service specialities are specific to each each of the providers in the UK market and, furthermore, that bundling likelihood is different depending upon the service. The inclusion of interaction variables in equation (6.6) is designed to capture and control for these effects. Specifically, it is not sufficient to examine bundling as being independent of providers or service, because the bundling rate across firms or services is fundamentally different. Interacting bundling with service or supplier actively accounts and allows for these heterogeneities. Similarly, by interacting service and supplier the model takes into account the observation that switching rates for each service are different depending upon the supplier.

The presence of multiple interaction terms presents challenges in terms of model interpretation. It means that in order to interpret to estimated coefficients it is necessary to explore the estimated propensities to switch under different service-supplier-bundling combinations, or otherwise explore the marginal effect for a change in variable from one state to another (i.e. unbundled to bundled). Section 6.2.1 outlines this process.

The interaction terms are limited to service-specific elements and although there may be demographic-related interaction terms, parsimony dictates that these are not included.

The problem faced in the analysis is that although all the above factors are influen-

tial in the individual's propensity to switch the supplier for the services to which they subscribe, it is not possible to actually observe the true propensity to switch. Instead we observe only whether an individual of particular characteristics, who subscribed to a particular service through a given supplier, decided to switch provider. This switching decision is therefore a binary variable. This binary nature of the dependent variable leads this study to utilise a probit technique which places an upper bound on the dependent variable, while the characteristics of the survey participants and their services are used as independent variables in order to analyse their respective significance in the determination of the decision to switch.

6.1.1. Binary Choice

In order to more formally understand the individual's decision to switch provider it is useful to interpret the choices made by the individual in a random utility framework, as per Greene [2012]. Defining U^0_{ik} as the utility individual i gains from their existing subscription to the service k with their current supplier, and U^1_{ik} the expected utility they could gain from switching to a new supplier.

$$U^0_{ik} = (\mathbf{x}^0_{ik})'\beta^0 + \mathbf{z}'_i\gamma^0 + \varepsilon^0_{ik} \tag{6.1}$$

$$U^1_{ik} = (\mathbf{x}^1_{ik})'\beta^1 + \mathbf{z}'_i\gamma^1 + \varepsilon^1_{ik} \tag{6.2}$$

From equation (6.1), the individual's utility from their existing subscription (U^0_{ik}) can be expressed as some function of a vector of characteristics of the product denoted $\mathbf{x}^0_{ik}$ which might include some supplier-specific elements, the age of the subscription, or whether it is bundled with other services in a single package. The utility gained from a service is also affected by the profile of the subscriber, thus a vector of individual demographic characteristics ($\mathbf{z}_i$) is included in the utility function. Utility from a service is also subject to some random error term ε^0_{ik}.

Equation (6.2) indicates a similar arrangement for utility with a new supplier of the same service (indicated by U^1_{ik}) and so features the characteristics of the new supplier; note that the demographic vector $\mathbf{z}_i$ remains constant since these are individual-specific

characteristics and do not vary with service.

An individual who wishes to change supplier for a service may also face a switching cost (W). This can be linked to the characteristics of the new service such as the efforts the new supplier makes to alleviate problems the individual may face in switching[44], the characteristics of the old supplier such as the efforts it makes to hinder a switching process, and also the characteristics of the individual such as their cognitive capacity to understand switching processes.

$$W_{ik}^{0\to1} = (\mathbf{x}_{ik}^{0})'\beta^{W0} + (\mathbf{x}_{ik}^{1})'\beta^{W1} + \mathbf{z}_{i}'\gamma^{W} + \varepsilon_{ik}^{W} \tag{6.3}$$

The switching equation captures the endogenous nature of switching costs in that both existing and future suppliers can create switching costs meaning that it is dependent on some or all of the firm-level variables. It also captures the reality that switching costs vary between the service k and the supplier. Finally, it includes demographics to account for the differences in perceived switching costs between different observable demographic groups such as the elderly.

A consumer is assumed to switch if they receive positive net-utility following that switch, defining net utility from switching as N_{ik}, where $W_{ik}^{0\to1}$ represents the switching cost associated with the switch from provider 0 to provider 1:

$$(\text{Net utility})_{ik}^{0\to1} \quad = \quad U_{ik}^{1} - U_{ik}^{0} - W_{ik}^{0\to1} \tag{6.4}$$

If the net utility from switching is greater than zero, then the individual will switch[45]; thus the probility of a switch is the probability that $(\text{Net utility})_{ik}^{0\to1} > 0$; from the above, this is where $U_{ik}^{1} > (U_{ik}^{0} + W_{ik}^{0\to1})$:

[44] This is typical of bank accounts where the receiving bank will offer to transfer over standing orders and direct debit instructions.

[45] A switch occurs in equation (6.5) where $Switch_{ik} = 1$, otherwise $Switch_{ik} = 0$

$$\begin{aligned}
\text{Prob}[Switch_{ik} = 1|\mathbf{x}^0_{ik}, \mathbf{x}^1_{ik}, \mathbf{z}_{ik}] &= \text{Prob}[U^1_{ik} > (U^0_{ik} + W^{0\to1}_{ik})] \qquad (6.5)\\
&= \text{Prob}[((\mathbf{x}^1_{ik})'\beta^1 + \mathbf{z}'_i\gamma^1 + \varepsilon^1_{ik}) - ((\mathbf{x}^0_{ik})'\beta^0 + \mathbf{z}'_i\gamma^0 + \varepsilon^0_{ik}) +\\
&\quad -((\mathbf{x}^0_{ik})'\beta^{W0} + (\mathbf{x}^1_{ik})'\beta^{W1} + \mathbf{z}'_i\gamma^W + \varepsilon^W_{ik}) > 0|\mathbf{x}^0_{ik}, \mathbf{x}^1_{ik}, \mathbf{z}_{ik}]\\
&= \text{Prob}[(\mathbf{x}^1_{ik})'(\beta^1 - \beta^{W1}) - (\mathbf{x}^0_{ik})'(\beta^0 - \beta^{W0}) +\\
&\quad +\mathbf{z}'_i(\gamma^1 - \gamma^0 - \gamma^W) + (\varepsilon^1_{ik} - \varepsilon^0_{ik} - \varepsilon^W_{ik}) > 0|\mathbf{x}^0_{ik}, \mathbf{x}^1_{ik}, \mathbf{z}_{ik}]\\
&= \text{Prob}[(\mathbf{x}^*_{ik})'\boldsymbol{\beta}^* + \mathbf{z}'_i\boldsymbol{\gamma}^* + \varepsilon^*_{ik} > 0|\mathbf{x}^*_{ik}, \mathbf{z}_{ik}] \qquad (6.6)
\end{aligned}$$

Where the term $\mathbf{x}^*_{ik}$ in equation 6.6 represents the appended vectors $\mathbf{x}^1_{ik}$ and $\mathbf{x}^0_{ik}$, the the vector of relevant β terms has been similarly appended and are represented by $\boldsymbol{\beta}^*$. The term $\boldsymbol{\gamma}^*$ represents the net effect of the γ terms on the service-invariant individual characteristics ($\mathbf{z}_{ik}$), expressed as $\gamma^1 - \gamma^0 - \gamma^{\mathrm{W}}$. The random error terms have been similarly consolidated (ε^*_{ik}).

6.1.2. Probit Estimation

Because the individual above is making their switching based upon an unobserved utility function then the true decision making process (based upon the net utility calculation) cannot be estimated. The decision made by the individual is however observed as the binary switching decision, in addition to a selection of characteristics of the individual and also a selection of service specific variables. Although equation (6.4), which is based upon the true utility function, may contain every possible characteristic of individual, we have a limited set of observed variables chosen to be relevant and measurable. As a result it is possible to estimate the decision by individual i to switch service k as some latent variable S_{ik} - a function of the observed characteristics included in the vectors $\mathbf{x}$ and $\mathbf{z}$ which again correspond to, respectively, service- and individual-specific variables. In the following equations the asterisks on the above variables are relaxed, though the term $\mathbf{x}$ still represents all service-specific variables and the term β the corresponding coefficients for the full set of service variables:

$$S_{ik} \quad = \quad \mathbf{x}'_{ik}\beta + \mathbf{z}'_i\gamma + \varepsilon_{ik} \tag{6.7}$$

Equation (6.7) is based upon the earlier notation, it is identical in form to the net utility calculation in equation (6.6) but can be calculated as it is constructed using observable characteristics. Where $\mathbf{x}_{ik}$ represents the subset of *observable* service-specific variables for individual i and the service k to which they subscribe.$\mathbf{z}_i$ represents those *observable* individual-specific variables. Thus, much like the net utility calculation of (6.6) the decision to switch is implicitly illustrated by the condition:

$$\text{Switch}_{ik} = \left\{ \begin{array}{l} 1 \text{ if } S_{ik} \geq 0 \\ 0 \text{ if } S_{ik} < 0 \end{array} \right\} \tag{6.8}$$

Thus, from (6.7) and (6.8) the probability that the individual switches is:

$$\text{Prob}[S_{ik} \geq 1] \quad = \quad \text{Prob}[\varepsilon_{ik} > -\mathbf{x}'_{ik}\beta - \mathbf{z}'_i\gamma] \tag{6.9}$$

By assuming the error term ε_{ik} to be normally distributed according to $\varepsilon_{ik} \sim N[0,1]$, which is symmetrical, the above can be rewritten:

$$\text{Prob}[S_{ik} \geq 1] \quad = \quad \text{Prob}[\mathbf{x}'_{ik}\beta + \mathbf{z}'_i\gamma > \varepsilon_{ik}] \tag{6.10}$$

In imposing the standard normal distribution on the error term the *probit* model is being used, as such, the standard normal distribution function is used in calculating the probability of switching ($S_{ik} > 0$):

$$\text{Prob}[Switch_{ik} = 1] \quad = \quad \int_{-\infty}^{\mathbf{x}'_{ik}\beta+\mathbf{z}'_i\gamma} \phi(S_{ik})dS_{ik} = \Phi(\mathbf{x}'_{ik}\beta + \mathbf{z}'_i\gamma) \qquad (6.11)$$

Where ϕ is the standard normal distribution and Φ the cumulative density function for the normal distribution; where $\Phi(S_{ik} > 0) > 0.5$, creating a positive probility of switching. The probit model is calculated using maximum likelihood estimation.

6.1.3. Random Effects Probit

Because the participants of the survey were asked their switching decisions over a range of services to which they subscribed, and because this analysis examines the switching decision on a per-service level, then for each individual there exists multiple data points; up to four (representing the four services in the study) dependent binary switching decisions.

The standard probit model is an acceptable model under the assumption of independence between different dependent variables; in the current case this would require complete independence of the decisions of an individual. Because the probit model estimates a single set of coefficients relating to the likelihood of switching a given service, independence would require that the error terms relating to the each individuals multiple service-specific switching decisions be independent. Suppose however that this is not the case, that for services k and l, and individuals i and j:

$$Cov[\varepsilon_{ik}, \varepsilon_{il}] \quad \neq \quad 0 \text{ and...}$$

$$Cov[\varepsilon_{ik}, \varepsilon_{jk}] \quad = \quad 0$$

This would imply that there is some exogenous deterministic element (in this case the individual's identity) which leads to correlation between the likelihood of switching for the services to which a single individual subscribes, but is otherwise uncorrelated with the rest of the variables. In this instance, pooling of the observations is not suitable and will result in inconsistent estimators.

The existence of intra-individual correlation in their decisions means that the analysis is approached as one would approach panel data; with multiple observation points for each individual. The probit model is adapted as a random effects model where the estimated coefficients are fixed for each service, supplier, and demographic characteristic, but a random individual specific error is added to all data points pertaining to a given individual. As such, the random effects probit estimation of the latent variable model becomes:

$$S_{ik} = \mathbf{x}'_{ik}\beta + \mathbf{z}'_i\gamma + e_{ik} \text{ where } e_{ik} = u_i + \varepsilon_{ik},\ u_i \sim N[0, \sigma_u^2],\ \varepsilon_{ik} \sim N[0,1] \quad (6.12)$$

Where the total error term e_{ik} is made up of the *individual* component u_i and the *random* component ε_{ik} which is still subject to the prior assumption regarding its normal distribution.

This extra error term allows for some undefinable individual difference in the probability of switching that cannot be accounted for by that individual's observable characteristics; it may be related to background or personal experience which cannot be readily quantified. The probability of switching, as per the model of equation (6.11), becomes as follows:

$$\text{Prob}[Switch_{ik} = 1] = \Phi(\mathbf{x}'_{ik}\beta + \mathbf{z}'_i\gamma + u_i) \quad (6.13)$$

This indicates that the probability of switching is still determined by the cumulative density function of the standard normal (as determined by the distribution of ε_{ik}), but the function of the latent variable is now augmented by the individual-specific error component, u_i, which is normally distributed according to $u_i \sim [0, \sigma_u^2]$.

6.1.4. Testing the Random Effects Specification

Although this investigation utilises the random effects probit model there are a number of other methods that could alternatively have been used. These include pooling the

data and thus disregarding individual-specific heterogeneity which would be appropriate where the differences between individuals are likely to be small or insignificant. Otherwise it would be possible to relax the assumption that the standard errors of estimated coefficients are independently distributed - allowing them to be non-independent for within-individual observations. This latter approach affects the standard errors of the estimated coefficients, but the log-likelihood and coefficients remain unbiased and identical to the unmodified probit.

It is necessary to determine whether the random effects model provides a better fitting model than the above approaches. The econometric specification of the latent variable for the random effect probit model is below, where :

$$S_{ik} = \alpha + x'_{ik}\beta + z'_i\gamma + \underbrace{u_i + \varepsilon_{ik}}_{e_{ik}}$$

Because the panel-specific error component u_i is distributed according to $u_i \sim N[0, \sigma_u^2]$ the total variance in the model is equal to $1 + \sigma_u$ according to the existing distributional assumptions concerning the random element ε_{ik}.
The proportion of the total variance which is attributable to the panel-specific error component, ρ, is calculated, for services k and l, as:

$$Corr(u_{ik}, u_{il}, k \neq l) \equiv \rho = \frac{\sigma_u^2}{1 + \sigma_u^2} \tag{6.14}$$

In the instance that there is no panel-specific effect (and that every observation in the dependent variable data is independent) then $\rho = 0$ and as such a pooled probit model featuring all the data would be more efficient. In order to test that ρ is non-zero and significant a likelihood-ratio test is performed against the null hypothesis that $\rho = 0$. A test statistic LR is calculated as:

$$LR = -2(LogLikelihood_0) + 2(LogLikelihood_1)$$

Where $LogLikelihood_0$ is the log likelihood under the restriction that $\rho = 0$ which is achieved by running a pooled probit (where all observations are assumed to be independent), and $LogLikelihood_1$ the log likelihood under the random effects specification. The LR statistic follows a *chi-squared* distribution with degrees of freedom equal to $Df_1 - Df_0$ (the difference in degrees of freedom between the experimental and null specifications), which is 1 in this case owing to the extra individual-specific error component. Section 6.3 details the results of the likelihood ratio test.

6.2. Final Model Specifications

This part of the thesis follows two main avenues of investigation. It first investigates the relative performance of a model primarily constructed using demographic variables against one which is instead constructed using service-specific variables. It then investigates the role of service bundling on individuals' switching decisions under the broad hypothesis that the bundling of services reduces the likelihood of an individual switching. The variables, and the symbols associated with their respective estimated coefficients are as those outlined in the previous section.

6.2.1. Demographic variables versus service-specific variables

The results from this section have implications for the significance of the conclusions elicited from prevailing literature because of its heavy focus on demographic variables. Specifically, this line of investigation aims to demonstrate that the implicit assumption of homogeneity of supplier, present in much of the previous literature, is flawed because the differences between suppliers affect the likelihood of switching. The firms in the present analysis have been shown to vary in terms of services in which they specialise (their 'specific' asset). They also vary in the extent to which subscribers of their services are likely to bundle services. Consequently where different propensities to switch provider are associated with different services, or the bundling of services, then this will be reflected in inter-firm differences in switching likelihood.

To examine the differences in performance between demographic-based models and those which are service-focussed three different specifications of the random-effects probit model (detailed in section 6.1.3) are utilised. In each case, the results assess the significance of the estimated coefficients against predictions informed by the existing literature. The random effects specification is also tested against a pooled model for each of the specifications being examined using a likelihood ratio test. Finally, the performance of the three models is compared so as to determine which is most appropriate in terms of assessing the impact of different variables on individuals' probability of switching provider. This is achieved by using Akaike's Information Criterion (AIC) – a goodness of fit measure which guards against over-fitting.

The following specifications feature the latent dependent variable S_{ik} and assumes that the decision to switch is distributed around this variable, such that:

$$\text{Switch}_{ik} = \left\{ \begin{array}{l} 1 \text{ if } S_{ik} \geq 0 \\ 0 \text{ if } S_{ik} < 0 \end{array} \right\}$$

Specification One - Demographic model:

The demographic-only model is based upon those variables which have been consistently significant in the prevailing switching literature. The model also controls for the market in which the switching is taking place. This is vital and common to many studies of switching since the underlying rate of switching varies between markets and, as such, would lead to inaccurate estimates of coefficients if not controlled for.

The assumption in testing only demographics here is that all suppliers are homogeneous and that, accordingly, the likelihood of switching-to or -from is identical for each supplier. In reality the different strategies of suppliers renders the assumption unrealistic; this is highlighted in the discussion of section 5.

The demographics-focussed random effects Probit model is laid out below:

$$\begin{aligned} S_{ik} \quad = \quad & \alpha + \left(\underset{[0,1]}{\beta_{\text{TV},0}\text{TV}_{ik}} + \underset{[0,1]}{\beta_{\text{BB},0}\text{BB}_{ik}} + \underset{[0,1]}{\beta_{\text{Mob},0}\text{Mob}_{ik}} + \underset{[0,1]}{\beta_{\text{LL},0}\text{LL}_{ik}} \right) \\ & + \sum_{\gamma_1}^{\gamma_7} \text{INCOME}_i^* + + \underset{[0,1]}{\gamma_8\text{Children}_i} + \sum_{\gamma_9}^{\gamma_{15}} \text{EMPLOYMENT}_i^* + \\ & + \underset{[0,1]}{\gamma_{16}\text{Gender}_i} + \sum_{\gamma_{17}}^{\gamma_{22}} \text{EDUCATION}_i^* + \sum_{\gamma_{23}}^{\gamma_{30}} \text{AGE}_i^* + u_i + \varepsilon_{ik} \end{aligned}$$

The variables INCOME*, EMPLOYMENT*, EDUCATION* and AGE* represent a categorical series of dummy variables. For each individual, i, the constituent dummies within each category are mutually exclusive such that only one of the related coefficients has an impact, the rest are equal to zero. Similarly, because there are multiple data points for each individual,[46] and each market is examined separately, the particular service (k) is mutually exclusive.

[46] Where the 'individual' represents a household

Example 1: The coefficients which are included in any estimation are demonstrated using the following example. Individual i has a household income of £33,000, has children in the household, is in full-time employment, is female, left education at age 20, and is 43 years old. The decision of this individual to switch service k = pay-TV in the last twelve months is indicated by the regression:

$$\begin{aligned} S_{ik} &= \alpha + \beta_{\text{TV},0}\underset{[=1]}{\text{TV}_{ik}} + \gamma_4\underset{[=1]}{\text{INCOME 30000-49999}_i} + \gamma_8\underset{[=1]}{\text{Children}_i} + \\ &\quad + \gamma_9\underset{[=1]}{\text{EMPLOY Full-time}_i} + \gamma_{20}\underset{[=1]}{\text{EDU 19-20}_i} + \gamma_{26}\underset{[=1]}{\text{AGE 35-44}_i} + u_i + \varepsilon_{ik} \end{aligned}$$

Because all the variables involved are mutually exclusive categorical variables, only the relevant categories are included, the rest are equal to zero and drop out of the estimation. Furthermore, since the included dependent variables all have a value of 1, the above regression is further simplified, thus:

$$S_{ik} = \alpha + \beta_{\text{TV},0} + \gamma_4 + \gamma_8 + \gamma_9 + \gamma_{19} + \gamma_{26} + u_i + \varepsilon_{ik}$$

Example 2: Again, utilising the relevant tables in section 5.1, suppose individual j has household income of £18,000, has no children, is employed part-time, is male, left education at 24, and is 30 years old; the probability of switching service k = broadband is based upon the equation:

$$S_{jl} = \alpha + \beta_{\text{BB},0} + \gamma_3 + \gamma_{10} + \gamma_{16} + \gamma_{20} + \gamma_{25} + u_i + \varepsilon_{ik}$$

Once estimated, the coefficients for the variables in this demographic specification are intuitively understood. Their interpretation does not rely on the calculation of marginal effects or estimated values of S_{ik} which are necessary in later specifications. The categorical variables, being a series of dummy variables, are expressed relative to some base category which is set to be informative (a comparable category rather than 'refused' or 'don't know'). The literature has informed a-priori expectations about the

relative magnitude of the dummy variables in each category; these are commented on in the results.

Specification Two - Service-specific model:

The service-specific model only includes variables relevant to the service to which an individual subscribes and disregards the demographic profile of the individual. This specification is a marked departure from much of the prevailing literature since the implicit homogeneity of the suppliers is removed.

Different advantages in the provision of certain services and strategies concerning bundling of products mean that the likelihood of switching provider is likely to vary significantly depending on the identity of the incumbent supplier and the service. Regression (6.15), below, sets out the service-specific model specification:

Much like the demographic-focussed model, the above model is constructed using a large number of mutually exclusive dummy variables. This means that when the characteristics of an individual's subscription are specified the model collapses to a much more manageable equation.

Example 3: The manner in which the above specification reduces is best illustrated using a simple example. Suppose that, amongst other services, an individual i subscribes to k, a pay-TV service, through Virgin and that this is included in a bundle; furthermore the individual has subscribed to this TV service for 18 months. Because in this instance k refers to pay-TV then the terms BB_{ik}, Mob_{ik}, and LL_{ik} are all equal to zero, eliminating lines 3-5 of the specification. Moreover, because k is supplied by Virgin, the terms BT_{ik}, Sky_{ik}, Talk_{ik}, MobFirm_{ik}, and Other_{ik} are also equal to zero; eliminating lines 6-8 and 10-11. Consulting section 5.2.5, the relevant coefficient for for TV×Virgin in line 2 is $\beta_{\text{TV},4}$, and the relevant coefficient for duration 18 months is β_{15}. Thus the model to be estimated, with lines 2 and 9 enabled by virtue of $\text{TV}_{ik} = 1$ and $\text{Virg}_{ik} = 1$, is expressed thus:

$$
\begin{aligned}
S_{ik} \;=\;& \alpha + \\
& + \underset{[0,1]}{\mathrm{TV}_{ik}} \left(\beta_{\mathrm{TV},0} + \sum_{\beta_{\mathrm{TV},1}}^{\beta_{\mathrm{TV},6}} \mathrm{SUPPLIER}^{*}_{ik} + \beta_{\mathrm{TV},7} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{TV},8}}^{\beta_{\mathrm{TV},13}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{BB}_{ik}} \left(\beta_{\mathrm{BB},0} + \sum_{\beta_{\mathrm{BB},1}}^{\beta_{\mathrm{BB},6}} \mathrm{SUPPLIER}^{*}_{ik} + \beta_{\mathrm{BB},7} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{BB},8}}^{\beta_{\mathrm{BB},13}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{Mob}_{ik}} \left(\beta_{\mathrm{Mob},0} + \sum_{\beta_{\mathrm{Mob},1}}^{\beta_{\mathrm{Mob},6}} \mathrm{SUPPLIER}^{*}_{ik} + \beta_{\mathrm{Mob},7} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{Mob},8}}^{\beta_{\mathrm{Mob},13}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{LL}_{ik}} \left(\beta_{\mathrm{LL},0} + \sum_{\beta_{\mathrm{LL},1}}^{\beta_{\mathrm{LL},6}} \mathrm{SUPPLIER}^{*}_{ik} + \beta_{\mathrm{LL},7} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{LL},8}}^{\beta_{\mathrm{LL},13}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{BT}_{ik}} \left(\beta_{\mathrm{BT},14} + \beta_{\mathrm{BT},15} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{BT},16}}^{\beta_{\mathrm{BT},21}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{Sky}_{ik}} \left(\beta_{\mathrm{Sky},14} + \beta_{\mathrm{Sky},15} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{Sky},16}}^{\beta_{\mathrm{Sky},21}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{Talk}_{ik}} \left(\beta_{\mathrm{Talk},14} + \beta_{\mathrm{Talk},15} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{Talk},16}}^{\beta_{\mathrm{Talk},21}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{Virg}_{ik}} \left(\beta_{\mathrm{Virg},14} + \beta_{\mathrm{Virg},15} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{Virg},16}}^{\beta_{\mathrm{Virg},21}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{MobFirm}_{ik}} \left(\beta_{\mathrm{MobF},14} + \beta_{\mathrm{MobF},15} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{MobF},16}}^{\beta_{\mathrm{MobF},21}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{Other}_{ik}} \left(\beta_{\mathrm{Oth},14} + \beta_{\mathrm{Oth},15} \underset{[0,1]}{\mathrm{Bundled}_{ik}} + \sum_{\beta_{\mathrm{Oth},16}}^{\beta_{\mathrm{Oth},21}} \mathrm{DURATION}^{*}_{ik} \right) + \\
& + \underset{[0,1]}{\mathrm{Bundled}_{ik}} \left(\beta_{22} + \sum_{\beta_{23}}^{\beta_{28}} \mathrm{DURATION}^{*}_{ik} \right) + \sum_{\beta_{29}}^{\beta_{34}} \mathrm{DURATION}^{*}_{ik} + u_i + \varepsilon_{ik}
\end{aligned}
\tag{6.15}
$$

$$
\begin{aligned}
S_{ik} \quad = \quad & \alpha + \beta_{\mathrm{TV},0}\underset{[=1]}{\mathrm{TV}_{ik}} + \beta_{\mathrm{TV},4}(\underset{[=1]}{\mathrm{TV}_{ik}} \times \underset{[=1]}{\mathrm{Virgin}_{ik}}) + \beta_{\mathrm{TV},7}(\underset{[=1]}{\mathrm{Bundled}_{ik}} \times \underset{[=1]}{\mathrm{TV}_{ik}}) + \\
& + \beta_{\mathrm{TV},10}(\mathrm{DUR}\ \underset{[=1]}{\text{1yr-2yr}_{ik}} \times \underset{[=1]}{\mathrm{TV}_{ik}}) + \beta_{\mathrm{Virg},14}\underset{[=1]}{\mathrm{Virgin}_{ik}} + \beta_{\mathrm{Virg},15}(\underset{[=1]}{\mathrm{Bundled}_{ik}} \times \underset{[=1]}{\mathrm{Virgin}_{ik}}) + \\
& + \beta_{\mathrm{Virg},18}(\mathrm{DUR}\ \underset{[=1]}{\text{1yr-2yr}_{ik}} \times \underset{[=1]}{\mathrm{Virgin}_{ik}}) + \beta_{22}\underset{[=1]}{\mathrm{Bundled}_{ik}} + \\
& + \beta_{25}(\mathrm{DUR}\ \underset{[=1]}{\text{1yr-2yr}_{ik}} \times \underset{[=1]}{\mathrm{Bundled}_{ik}}) + \beta_{31}(\mathrm{DUR}\ \underset{[=1]}{\text{1yr-2yr}_{ik}}) + u_i + \varepsilon_{ik}
\end{aligned}
$$

Given that all the variables are dummy variables with the value 1, the notation can be further reduced thus:

$$
\begin{aligned}
S_{ik} \quad = \quad & \alpha + \beta_{\mathrm{TV},0} + \beta_{\mathrm{TV},4} + \beta_{\mathrm{TV},7} + \beta_{\mathrm{TV},10} + \beta_{\mathrm{Virg},14} + \beta_{\mathrm{Virg},15} + \\
& + \beta_{\mathrm{Virg},18} + \beta_{22} + \beta_{25} + \beta_{31} + u_i + \varepsilon_{ik}
\end{aligned} \tag{6.16}
$$

Like the demographic specification before, there is enough variation across the whole sample to allow estimation of all the coefficients in the model. The interpretation of the coefficients is not straightforward in this particular model since the majority of the variables are included in both standalone and also interacted form; this is addressed in discussion following specification three.

Specification Three - Unified model:

The third model specification combines the previous specifications one and two and is designed to measure the impact of the different service-specific factors while controlling for the demographic profile of the subscriber. The notation remains the same though now the β coefficients and γ coefficients (referring to, respectively, service and demographic variables) are present in the same model. Because the model still utilises the dummy-variable basis it similarly reduces according to the characteristics of the individual-service (ik) combination as per examples 1-3.

The specification of the unified model is outlined below:

Because, both in this specification and the previous, all of the service-specific vari-

$$
\begin{aligned}
S_{ik} \;=\;& \alpha + \qquad (6.17)\\
&+\underset{[0,1]}{\mathrm{TV}_{ik}}\left(\beta_{\mathrm{TV},0}+\sum_{\beta_{\mathrm{TV},1}}^{\beta_{\mathrm{TV},6}}\mathrm{SUPPLIER}^{*}_{ik}+\beta_{\mathrm{TV},7}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{TV},8}}^{\beta_{\mathrm{TV},13}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{BB}_{ik}}\left(\beta_{\mathrm{BB},0}+\sum_{\beta_{\mathrm{BB},1}}^{\beta_{\mathrm{BB},6}}\mathrm{SUPPLIER}^{*}_{ik}+\beta_{\mathrm{BB},7}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{BB},8}}^{\beta_{\mathrm{BB},13}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{Mob}_{ik}}\left(\beta_{\mathrm{Mob},0}+\sum_{\beta_{\mathrm{Mob},1}}^{\beta_{\mathrm{Mob},6}}\mathrm{SUPPLIER}^{*}_{ik}+\beta_{\mathrm{Mob},7}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{Mob},8}}^{\beta_{\mathrm{Mob},13}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{LL}_{ik}}\left(\beta_{\mathrm{LL},0}+\sum_{\beta_{\mathrm{LL},1}}^{\beta_{\mathrm{LL},6}}\mathrm{SUPPLIER}^{*}_{ik}+\beta_{\mathrm{LL},7}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{LL},8}}^{\beta_{\mathrm{LL},13}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{BT}_{ik}}\left(\beta_{\mathrm{BT},14}+\beta_{\mathrm{BT},15}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{BT},16}}^{\beta_{\mathrm{BT},21}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{Sky}_{ik}}\left(\beta_{\mathrm{Sky},14}+\beta_{\mathrm{Sky},15}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{Sky},16}}^{\beta_{\mathrm{Sky},21}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{Talk}_{ik}}\left(\beta_{\mathrm{Talk},14}+\beta_{\mathrm{Talk},15}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{Talk},16}}^{\beta_{\mathrm{Talk},21}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{Virg}_{ik}}\left(\beta_{\mathrm{Virg},14}+\beta_{\mathrm{Virg},15}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{Virg},16}}^{\beta_{\mathrm{Virg},21}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{MobFirm}_{ik}}\left(\beta_{\mathrm{MobF},14}+\beta_{\mathrm{MobF},15}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{MobF},16}}^{\beta_{\mathrm{MobF},21}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{Other}_{ik}}\left(\beta_{\mathrm{Oth},14}+\beta_{\mathrm{Oth},15}\underset{[0,1]}{\mathrm{Bundled}_{ik}}+\sum_{\beta_{\mathrm{Oth},16}}^{\beta_{\mathrm{Oth},21}}\mathrm{DURATION}^{*}_{ik}\right)+\\
&+\underset{[0,1]}{\mathrm{Bundled}_{ik}}\left(\beta_{22}+\sum_{\beta_{23}}^{\beta_{28}}\mathrm{DURATION}^{*}_{ik}\right)+\sum_{\beta_{29}}^{\beta_{34}}\mathrm{DURATION}^{*}_{ik}+\\
&+\sum_{\gamma_1}^{\gamma_7}\mathrm{INCOME}^{*}_{i}++\gamma_8\underset{[0,1]}{\mathrm{Children}_{i}}+\sum_{\gamma_9}^{\gamma_{15}}\mathrm{EMPLOYMENT}^{*}_{i}+\\
&+\gamma_{16}\underset{[0,1]}{\mathrm{Gender}_{i}}+\sum_{\gamma_{17}}^{\gamma_{21}}\mathrm{EDUCATION}^{*}_{i}+\sum_{\gamma_{22}}^{\gamma_{29}}\mathrm{AGE}^{*}_{i}+u_i+\varepsilon_{ik}
\end{aligned}
$$

ables are included in an interacted form the interpretation of their estimated coefficients is neither straightforward not intuitive. This is because the impact of a change in one variable will be dependent upon the other variables with which it is interacted. In order to understanding the impact of the different service-specific variables it is necessary to estimate values of the dependent variable S_{ik} given different service combinations.

Estimating values of S_{ik}: Where variables are discrete and categorical in nature, with many interactions, (but not necessarily representing any ascending or descending pattern) it is logical to estimate the switching equation and fit certain characteristics to the estimated model in order to gain estimated values of S_{ik} and compare these estimated values.

In the results section 6.3 the estimated values of S_{ik} are compared for each service-supplier combination under both bundled and non-bundled conditions. These are reported based upon holding demographic variables constant across all calculations at some median individual which is representative of the whole sample.[47]

[47] Specifying a median individual based upon the most common categorical variables means that all the demographic variables can be held constant. Though, because there are no interaction terms between demographic- and service-specific variables the marginal effects of bundling are actually independent of demographics

6.2.2. Goodness of Fit

One of the key aims of this paper is to determine whether models containing service-specific variables outperform the equivalent demographic-focussed model which has been popular in much of the literature. In order to compare the different model specifications the Akaike information Criterion (AIC), as outlined in section 3.3.1 of the previous part of the thesis, is employed. This is a measure of goodness of fit which penalises the inclusion of irrelevant variables.

In a maximum likelihood model, such as the probit, the AIC formula is expressed as below, where a smaller value of AIC implies a better fitting model:

$$AIC = 2Df - 2\ln(L)$$

Where Df represents the degrees of freedom of the model and $\ln(L)$ is the log-likelihood of the model.

The models in the present investigation involve many more variables than those employed in investigating exclusivity. As such the AIC can also be corrected for instances where the degrees of freedom is large relative to the number of observations. In this instance a second-order criterion (AIC_c) can be introduced which utilises the formula:

$$AIC_c = 2Df - 2\ln(L) + \frac{2Df(Df+1)}{n - Df - 1}$$

The AIC_c statistic converges to the standard AIC where the number of observations (n) is large. Burnham and Anderson [2004] suggest that this second technique should be used unless $n/Df > 40$ – beyond which the choice of AIC or AIC_c is unimportant. If there are concerns that the degrees of freedom are large relative to the number of observations then the AIC_c has a greater penalty for the inclusion of additional variables.

In the results section both the AIC and AIC_c results are reported.

6.2.3. Testing the Impact of Bundling

The second major hypothesis tested in this paper is that bundling of services with others from a single supplier reduces the likelihood of switching provider for that service. Because, as in the previous example, the variable 'Bundled' is interacted with several others it is not immediately obvious how to interpret the relevant coefficients.

Equation (6.18) indicates the marginal effect of bundling service k with at least one other service, compared to subscribing as a single standalone service.

$$\text{Marginal effect of bundling on } S_{ik} \quad = \quad \frac{\partial \mathrm{S}_{ik}}{\partial \mathrm{Bundled}_{ik}} \tag{6.18}$$

The marginal effect of bundling will vary depending on which supplier and service an individual subscribes. Thus marginal effects of bundling for a specific individual i and service k is calculated by varying only the 'Bundling' variable but holding all other variables constant. In section 6.3 the marginal effects of bundling (as calculated using (6.18)) are shown for every service-supplier combination for a specific median individual. The results indicate that, as expected, dependent upon the different suppliers and/or services, the impact of service bundling differs.

The broad hypothesised result as informed by the literature is that, irrespective of supplier or service, the marginal effect of bundling will always be negative in that it reduces the likelihood of switching.

6.3. Results and Discussion

This section summarises the findings of the empirical investigation and consists of three main sections. The first section offers a brief description of the results and comments upon the significance of the coefficients in the model. In this section the fitted values of S_{ik} are also reported for the different configurations of service and provider. The second section determines whether the service-specific model outperforms the demographic approach as indicated by goodness of fit measures of the three specifications. The third section discusses the impact of bundling of services on the likelihood of switching.

An additional discussion of the significance of the results with respect to the aims of this part of the thesis is located in the conclusion, while the full results table is reproduced in appendix C.

6.3.1. Analysing Variables

The following section examines the significance of the variables that were included across the three specifications. For the demographic variables (and also the service dummies in specification one), the sign and significance of the coefficients is examined and interpreted under both specifications one and three.

For the service specific variables, owing to the number of interaction variables included, the fitted values of S_{ik} are reported for the different permutations of service, supplier, and bundling status. Furthermore, in specification three the fitted values are reported for a median individual in order to hold the demographic variables constant. The significance of the duration variable is explored separately since this variable does not interact with any others and can be readily interpreted.

Demographic Variables

Table 6.1 indicates the estimated coefficients for those variables relating to demographic variables under specification one and specification three of the switching model. Because of the number of interaction variables involved in the estimation 6.1 is limited only to the specifications which feature demographics but omits the service-specific variables from specification three. Appendix C features the full results table for all models including specification two.

The first observation from table 6.1 is that, where an estimated coefficient is found to be significant in specification one, the level of this significance generally either decreases or disappears when the service-specific variables are included in specification three. The second observation is that most of the demographic variables seem to fit with a-priori expectations, as informed by the literature. The following sections address the results with respect to expectations.

Constant

Under both specifications the constant baseline likelihood of switching is negative and significant (though only at a 10% level in specification three); this is a reflection of the underlying low probability relative to the likelihood of not switching.

Service variables

The estimated coefficients relating services display the expected sign and significance relative to the Pay-TV variable. The market study in chapter 5 indicated that switching rates are comparatively low for pay-TV and thus the remaining services are relatively more likely to be switched.

The results from specification one indicate that broadband is most likely to be switched and this concurs with the characterisation of broadband markets as competitive, unsettled markets with high levels of entry, exit, and consolidation; also with high levels of switching.

That landline services appear to be those that are second-least likely to be switched may be unsurprising given that for smaller suppliers of broadband there remains a requirement that an individual also subscribes to landline through BT; resulting in lower switching rates than otherwise, absent this constraint. Because the service variables are interacted with other variables in specification three, the results for this specification are not reported.

Income

The results concerning income indicate that there may be a non-linear relationship between income level and the likelihood of switching which would fit with the seemingly

Table 6.1.: Estimated Coefficients for Demographic Variables

Variable	Category	Symbol	Specification One Coeff	SE	Specification Three Coeff	SE
Service	Pay-TV	$\beta_{\text{TV},0}$	(omitted)		-	-
	Broadband	$\beta_{\text{BB},0}$	0.806***	(0.067)	-	-
	Mobile	$\beta_{\text{Mob},0}$	0.432***	(0.066)	-	-
	Landline	$\beta_{\text{LL},0}$	0.374***	(0.067)	-	-
Income	Under 11,500	γ_1	(omitted)		(omitted)	
	11,500-17,499	γ_2	0.161	(0.113)	0.163	(0.122)
	17,500-29,999	γ_3	0.276***	(0.103)	0.240**	(0.111)
	30,000-49,999	γ_4	0.225**	(0.106)	0.2*	(0.114)
	50,000 and over	γ_5	0.117	(0.123)	0.027	(0.133)
	Don't know INCO	γ_6	-0.008	(0.119)	0.049	(0.129)
	Refused	γ_7	-0.371***	(0.103)	-0.341***	(0.111)
Children	Yes	γ_8	-0.148**	(0.063)	-0.137**	(0.068)
Employment	Full-time	γ_9	(omitted)		(omitted)	
	Part-time	γ_{10}	0.062	(0.079)	0.045	(0.086)
	Looking	γ_{11}	0.156	(0.157)	0.051	(0.169)
	Full-time Education	γ_{12}	-0.109	(0.172)	-0.135	(0.187)
	Retired	γ_{13}	0.071	(0.105)	0.077	(0.112)
	Not-working	γ_{14}	-0.04	(0.087)	-0.062	(0.094)
	Refused	γ_{15}	-0.141	(0.337)	-0.191	(0.367)
Gender	Male	γ_{16}	-0.065	(0.054)	-0.092	(0.059)
Age left education	Aged under 17	γ_{17}	(omitted)		(omitted)	
	Aged 17-18	γ_{18}	0.115	(0.071)	0.143*	(0.077)
	Aged 19-20	γ_{19}	0.254***	(0.094)	0.251**	(0.102)
	Aged 21 and over	γ_{20}	0.173**	(0.07)	0.123	(0.076)
	Don't know	γ_{21}	-0.12	(0.269)	-0.018	(0.293)
	Refused	γ_{22}	0.507	(0.431)	0.818*	(0.469)
Age	Aged under 18	γ_{23}	-0.458	(0.293)	-0.508	(0.315)
	Aged 18-24	γ_{24}	(omitted)		(omitted)	
	Aged 25-34	γ_{25}	0.061	(0.118)	0.037	(0.128)
	Aged 35-44	γ_{26}	-0.095	(0.122)	-0.089	(0.133)
	Aged 45-54	γ_{27}	-0.073	(0.121)	-0.018	(0.132)
	Aged 55-64	γ_{28}	-0.155	(0.13)	-0.143	(0.142)
	Aged 65-74	γ_{29}	-0.222	(0.153)	-0.265	(0.165)
	Aged 75 and over	γ_{30}	-0.674***	(0.213)	-0.74***	(0.229)
	Constant	α	-1.798***	(0.159)	-0.869*	(0.507)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

divergent predictions of Hausman and Sidak [2004] and Waddams Price and Webster [2011]. Specifically, those households in the middle income categories with incomes between £17,500 and £49,999 are more likely to switch than those in the lowest income categories (under £17,500) or those with higher income (£50,000 and over), but the positive impact on the likelihood of switching peaks in the category £17,500-£29,999.

This suggests that income *is* positively correlated with the likelihood of switching, but that at higher income levels this relationship disappears. When service-variables are included in specification three the significance level of the estimated income coefficients diminishes. An anomalous result concerns those household representatives who refused to divulge their income level, this group were significantly less likely to switch their services relative to all other income categories; this suggests that there may be some unobserved characteristic that is common to individuals which refuse to divulge information concerning their income.

Children

As predicted in Waddams Price and Webster [2011], the presence of children in the household has a significantly negative (at 5%) impact on the probability of switching (which diminishes to a 10% l.o.s. with the inclusion of service-specific variables). This fits with the conjecture concerning the availability of free-time, and the opportunity cost of time spent in switching-related activity.

Employment

The predictions of the literature are that those individuals who work full-time are less likely owing to the same type of opportunity cost issues as discussed above in relation to children; the results, however, indicate that there is no significant differences in the probability of switching between any of the employment categories.

Gender

There are few instances where gender has proven to be significant in determining the likelihood of consumer switching, though Ranganathan et al. [2006] find men to be significantly more likely to switch their mobile service provider. This weakly suggests that γ_{16} will be positive and significant, though the results in the present investigation

do not support this prediction.

Education

The education coefficients under both specifications one and three suggest a non-linear relationship between education and switching likelihood. Relative to the control group of those that left education under age 17, the coefficient relating to having left education aged 19-20 is positive and significant under both specification one and three. Under specification one the 21-and-over variable is positive and significant (though smaller than that for 19-20), while the 17-18 variable is positive but not significant; this is reversed under specification three.

Age

Age has been indicated as being significant with a variety of relationships; significant differences between the coefficients γ_{22} to γ_{29} would indicate that some ages groups are more or less likely to switch. This would support hypotheses such as lower likelihood from switching with increased age [Royalty and Solomon, 1999] or non-linear relationships [Waddams Price and Webster, 2011].The present investigation, however, indicates that there is no significant difference in the likelihood of switching between most of the age categories and the base category of 18-24. The exception is the category for those individuals aged 75 and over which is significantly negative under both specifications one and three, indicating that individuals in the oldest age category are least likely to switch provider.

Service-specific Variables

Specifications two and three include variables which specifically concern the services to which individuals subscribe. In specification two these variables alone are included, while in specification three the demographic variables are also included. Appendix C features the full results table for all three specifications.

In order to circumvent the issues associated with reporting the impact of variables in the presence of interaction terms the estimated coefficients from specifications two and three are used to generate expected values of S_{ik}. These can be used to show the difference in switching likelihood for different combinations of values.

The impact of duration is explored for different suppliers, holding service and bundling status constant. The opposite difference in switching likelihood for the full range of supplier-service combinations is examined - holding duration constant. In order to make comparisons a median individual is introduced based upon the most common demographic characteristics in order to hold demographic characteristics constant.

The full tables of expected values of S_{ik} for each service-supplier-duration-bundled combination are reported in appendix D while the results concerning the significance of bundling are discussed later in this section.

The Median Individual

A median individual is introduced which allows the analysis of service variables while holding demographics constant. This is possible because there are no interactions between service and individual variables - this demographic changes would only result in step changes to switching likelihood.

The features of the median individual are those characteristics that are most prevalent in each category of demographic variables. This hypothetical individual, which is used in order to hold demographic varaibles constant in the analysis of the results from specifications two and three. The median individual is a female who is aged between 25 and 34 and has no children. Furthermore, she left full time education aged 16 or under, works full-time, and has a household income of £30,000-£49,999.

Duration

The duration of a subscribers' relationship with suppliers affects the likelihood of switching in two ways; if the duration of a relationship is very short (under six months) then it is likely that this will significantly reduce the likelihood of switching provider owing to the prevalence of minimum-term subscription contracts. Similarly, if an individual has been with a provider for a long period of time, then this too reduces the likelihood of switching since it indicates that an individual is either fundamentally unlikely to switch services, or otherwise satisfied with their service.

Table 6.2 reports the expected values of S_{ik} for unbundled broadband subscribers,

Table 6.2.: Expected values of S_{ik} for broadband duration categories

	BT	Sky	Talk-Talk	Virgin	Mobile Operator	Other
6 months and under	-1.008 *** (0.38)	-0.506 (0.432)	-0.024 (0.465)	-1.491 *** (0.459)	-3.501 *** (0.714)	-1.628 *** (0.45)
7 to 12 months	-0.812 *** (0.287)	-0.589 * (0.349)	-0.365 (0.393)	-0.401 (0.322)	-0.222 (0.309)	0.2 (0.259)
13 to 24 months	-0.187 (0.198)	0.467 * (0.249)	-0.165 (0.266)	0.072 (0.23)	-0.233 (0.227)	0.079 (0.178)
25 to 48 months	0.287 (0.189)	0.538 * (0.296)	0.014 (0.283)	0.428 * (0.248)	0.264 (0.235)	0.186 (0.172)
Over 48 months	-0.192 (0.185)	0.227 (0.269)	-0.509 * (0.294)	-0.738 *** (0.232)	-0.454 * (0.238)	-0.389 ** (0.166)
Don't know	-0.708 * (0.393)	0.061 (0.57)	-5.831 (355.187)	-0.094 (0.441)	-1.359 * (0.732)	-0.226 (0.326)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

using the estimated coefficients from specification three. Broadband was chosen because switching rates are relatively high for this service. In order to isolate the effect of duration, the service and bundling status are being held constant, while the results are reported for each firm. Furthermore, because this table reports the expected values of S_{ik}, the magnitude and sign indicates the absolute probability of switching for each combination of variables. Where a result is reported as significant, then it is estimated to be significantly different from zero.

The results concerning duration show that when the length of an individual's relationship with their supplier is short (6 months and under) this has a strongly negative effect of on the probability of switching provider. This is signified by the more negative expected values of S_{ik} for the categories representing '6 months and under' and '7 to 12 months'. The expected values for the next two duration categories indicate that switching is most likely for broadband services held between one and four years; individuals which have subscribed to their broadband service for over four years are less likely to switch.

The results for unbundled landline subscribers exhibits a broadly similar pattern where individuals who have subscribed for only a short period, or otherwise a long pe-

Table 6.3.: Expected values of S_{ik} for landline duration categories

	BT	Sky	Talk-Talk	Virgin	Mobile Operator	Other
6 months and under	-1.994 *** (0.338)	-1.057 ** (0.452)	-0.529 (0.47)	-1.842 *** (0.513)	-3.782 *** (0.852)	-2.174 *** (0.515)
7 to 12 months	-1.766 *** (0.274)	-1.109 *** (0.377)	-0.838 ** (0.377)	-0.721 ** (0.343)	-0.471 (0.515)	-0.314 (0.286)
13 to 24 months	-1.197 *** (0.196)	-0.109 (0.275)	-0.694 *** (0.262)	-0.303 (0.279)	-0.538 (0.486)	-0.492 ** (0.215)
25 to 48 months	-0.572 *** (0.178)	0.113 (0.315)	-0.365 (0.261)	0.204 (0.271)	0.109 (0.485)	-0.234 (0.208)
Over 48 months	-1.139 *** (0.135)	-0.286 (0.289)	-0.975 *** (0.273)	-1.05 *** (0.245)	-0.696 (0.472)	-0.896 *** (0.211)
Don't know	-2.012 *** (0.388)	-0.809 (0.539)	-6.655 (355.187)	-0.765 * (0.457)	-1.959 ** (0.852)	-1.092 *** (0.387)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

riod, are significantly less likely to switch and the likelihood of switching is greatest in the middle periods. The landline results, shown in table 6.3, are particularly vivid for those individuals who subscribe through BT where the relationship between duration and switching likelihood is particularly strong.

Service and Supplier

The impact on switching likelihood of different service-supplier combinations can be observed in a similar fashion to that which used to examine the impact of duration. Tables 6.4 and 6.5 show the expected values of S_{ik} for the different permutations, both when demographic variables are included, and without. In order to show the information the duration has been held constant at '13 to 24 months'; tables 6.3 and 6.2 offer an indication of the relative impact of altering the duration.

Table 6.4 confirms the observation made in Ofcom [2008] that the likelihood of switching varies between service, with pay-TV being the least likely to be switched and broadband most likely. Section 5 also indicates that broadband markets are the most contested with multiple competing suppliers, whereas pay-TV is a near-duopoly.

Table 6.4.: Expected values of S_{ik} for **Unbundled** service-supplier combinations

	Specification Two						Specification Three					
	BT	Sky	Talk-Talk	Virgin	Mobile Operator	Other	BT	Sky	Talk-Talk	Virgin	Mobile Operator	Other
Pay-TV	-0.589 **	-1.802 ***	-0.171	-0.787 ***	-0.346	-0.101	-0.356	-1.596 ***	0.124	-0.547 **	-0.185	0.074
	(0.267)	(0.184)	(0.612)	(0.247)	(1.024)	(0.284)	(0.29)	(0.211)	(0.63)	(0.272)	(1.029)	(0.305)
Broadband	-0.399 **	0.258	-0.451 *	-0.187	-0.481 **	-0.153	-0.187	0.467 *	-0.165	0.072	-0.233	0.079
	(0.166)	(0.227)	(0.238)	(0.202)	(0.2)	(0.14)	(0.198)	(0.249)	(0.266)	(0.23)	(0.227)	(0.178)
Mobile	-0.391	0.598	-0.399	-0.487 **	-1.099 ***	-0.742 ***	-0.092	0.844	-0.173	-0.189	-0.823 ***	-0.431 *
	(0.384)	(0.719)	(0.638)	(0.224)	(0.086)	(0.211)	(0.4)	(0.734)	(0.664)	(0.252)	(0.137)	(0.243)
Landline	-1.427 ***	-0.349	-1.023 ***	-0.602 **	-0.739	-0.797 ***	-1.197 ***	-0.109	-0.694 ***	-0.303	-0.538	-0.492 **
	(0.166)	(0.254)	(0.233)	(0.255)	(0.472)	(0.184)	(0.196)	(0.275)	(0.262)	(0.279)	(0.486)	(0.215)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

Table 6.5.: Expected values of S_{ik} for **Bundled** Service-Supplier Combinations

	Specification Two						Specification Three					
	BT	Sky	Talk-Talk	Virgin	Mobile Operator	Other	BT	Sky	Talk-Talk	Virgin	Mobile Operator	Other
Pay-TV	-0.742 ***	-2.33 ***	-0.799	-2.176 ***	-0.33	-0.065	-0.481 *	-2.084 ***	-0.531	-1.909 ***	-0.24	0.104
	(0.265)	(0.228)	(0.568)	(0.261)	(0.997)	(0.372)	(0.289)	(0.248)	(0.585)	(0.284)	(0.999)	(0.389)
Broadband	-1.826 ***	-1.545 ***	-2.353 ***	-2.85 ***	-1.74 ***	-1.391 ***	-1.592 ***	-1.301 ***	-2.1 ***	-2.57 ***	-1.568 ***	-1.171 ***
	(0.178)	(0.196)	(0.261)	(0.249)	(0.419)	(0.214)	(0.209)	(0.219)	(0.284)	(0.27)	(0.436)	(0.241)
Mobile	-0.901 *	-0.288	-1.384 *	-2.233 ***	-1.441 ***	-1.063 **	-0.597	-0.024	-1.208	-1.93 ***	-1.257 ***	-0.781 *
	(0.485)	(0.755)	(0.713)	(0.433)	(0.461)	(0.453)	(0.501)	(0.779)	(0.749)	(0.452)	(0.478)	(0.474)
Landline	-2.135 ***	-1.433 ***	-2.207 ***	-2.546 ***	-1.28 **	-1.316 ***	-1.909 ***	-1.184 ***	-1.936 ***	-2.252 ***	-1.18 **	-1.049 ***
	(0.184)	(0.212)	(0.258)	(0.254)	(0.515)	(0.22)	(0.213)	(0.236)	(0.282)	(0.277)	(0.533)	(0.247)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

While a strong pattern concerning supplier is not immediately apparent in table 6.4 the results do suggest that switching a service is least likely where the incumbent provider of that service is the dominant provider or specialises in provision of the service. This is evidenced in the case of BT with landline services, Sky with pay-TV, or mobile firms with mobile phone services.

This dominant firm effect may be explained by a number of factors. It is possible that these firms' dominance is because they provide a product of higher quality, in which case it would be expected that subscribers are less likely to switch away from them, even if a lower price is offered by a rival, lower quality, supplier. Alternatively, this quality difference my not be related to actual quality, but may instead be linked to perceived quality and psychological prominence of the leading brand, such that there exists a 'fear' of moving to an alternative provider. This latter effect can be created artificially by the leading brands.

A third effect which may reduce switching from prime providers is that there may be other issues relating to network effects (or similar) in the subscription to certain subscribers. This can be through either direct effects through offers like 'free calls to fellow BT landline subscribers', or otherwise indirect effects such as TV channels which are not related to the production activities of Sky, but which are exclusively available to subscribers to Sky's pay-TV service.

Although the bundling of services has a dedicated section, the impact that bundling has on individuals' likelihood of switching provider can be seen in table 6.5. Where previously only selected services (those in which suppliers specialised) were significantly unlikely to be switched, when firms bundle their products the likelihood of an individual switching provider decreases. This is particularly apparent with Virgin, a firm which specialises in the bundling of services, such that where previously only pay-TV was significantly unlikely to be switched at a 5% level. Under bundling all of its services become significantly unlikely to be switched.

Testing the Random Effects Methodology

Because all three model specification employ a random effects methodology it is necessary to test the condition that $\rho \neq 0$ and that there exists an exogenous deterministic

variable which leads to inter-individual heterogeneity; in this case it is the identity of each respondent. As discussed in section 6.1.4 a likelihood-ratio test is employed; the results of which are indicated in table 6.6.

Table 6.6.: Likelihood Ratio Scores for Random Effects Probit

	Specification		
	(1)	(2)	(3)
$LogLikelihood_0$	-3304.43	-2957.38	-2899.73
$LogLikelihood_1$	-3202.75	-2860.89	-2806.28
LR	203.37***	192.98***	186.90***

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

The likelihood ratio statistics for all specifications are significant at less than 1% indicating that, indeed, $\rho \neq 0$ and as such a non-zero proportion of the total variance of the model is provided by the individual heterogeneity associated with the different individuals. This indicates that under each of the econometric specifications the random effects methodology is superior to simply pooling the data and running a pooled probit.

This result shows that there are significant underlying differences between individuals which affect their likelihood of switching provider for services which are not accounted for by variables included in the models in this paper.

6.3.2. Comparing Model Specifications

The present investigation set out to determine the effectiveness of service- and supplier-specific variables in explaining individuals switching behaviour, contrasted against models which heavily focus upon demographic factors. Specification one was designed to be similar in form to prevailing switching papers which take account of demographic-specific differences in switching propensity. Specification two contains only service-specific factors and is included as a stylised test of the demographic model against service-specific variables. Specification three contains both; featuring both service variables and also controlling for the demographic profile of the individuals in the survey.

Table 6.7.: Goodness of Fit (AIC and $AICc$)

Specification	Included variables	Obs.	Log-Likelihood	Df	AIC	AICc
1	Demographic	8628	-3202.75	31	6467.50	6467.733
2	Service	8628	-2860.89	84	5889.79	5891.46
3	Both	8628	-2806.28	110	5832.56	5835.43

Akaike's Information Criterion is employed to compare the performance of the different specifications, with the results shown in table 6.7 where a smaller value of AIC indicates a better fitting model. Because small samples relative to the number of explanatory variables can result in a bias in the AIC statistic, the statistics fior the second-order information criterion $AICc$ are also reported, though their similarity to the headline AIC statistics suggests that there is no danger of a bias[48].

Comparing the AIC statistics reveals that specifications two and three outperform specification one; this is especially notable given that specification two features no demographic variables.

Result 4 *Models featuring service- and supplier-specific variables outperform those which are constructed mainly using demographic variables, however controlling for these variables in a service-specific model results in a better fit than service variables alone.*

This result supports the idea that switching behaviour is heavily affected by the strategies of firms in terms of the services they offer, those in which they specialise, and the activities in which they engage in order to retain subscribers. It disproves the notion that suppliers can be considered as being homogeneous for the purposes of investigating switching behaviour.

[48] $AICc$ converges to AIC as the sample size tends toward infinity and the number of explanatory variables tends to one.

Table 6.8.: Marginal Impact of Bundling on S_{ik}

	BT	Sky	Talk-Talk	Virgin	Mobile Operator	Other
Pay-TV	-0.125 (0.242)	-0.488 ** (0.214)	-0.655 ** (0.303)	-1.362 *** (0.246)	-0.055 (0.447)	0.029 (0.272)
Broadband	-1.405 *** (0.182)	-1.768 *** (0.225)	-1.935 *** (0.249)	-2.642 *** (0.227)	-1.335 *** (0.412)	-1.25 *** (0.211)
Mobile	-0.504 (0.397)	-0.867 ** (0.416)	-1.034 ** (0.433)	-1.741 *** (0.4)	-0.434 (0.462)	-0.35 (0.413)
Landline	-0.712 *** (0.179)	-1.075 *** (0.234)	-1.242 *** (0.246)	-1.949 *** (0.232)	-0.642 (0.422)	-0.558 ** (0.219)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

6.3.3. The Impact of Bundling

The impact of bundling of services with a single provider on the likelihood of an individual switching supplier is the second key area of investigation. If bundling of services creates switching costs which serve to restrict consumer switching then there are implications concerning the ability of the handful of large multi-product incumbent firms to foreclose markets. While this may not lead to complete monopolisation of markets, it would serve to increase the concentration amongst a small number of firms.

Tables 6.4 and 6.5 show the impact that service bundling has on the likelihood of switching. When services are bundled the probability of switching those services decreases significantly. The difference between the unbundled and bundled fitted values of S_{ik} represents the marginal effect of bundling a service, expressed as $\frac{\partial S_{ik}}{\partial \text{Bundled}_{ik}}$.

The marginal effect of bundling is also shown in table 6.8 where duration is being held constant at '12 to 24 months'.[49] The results indicate that, at a highly significant level (1% in most cases) the probability of switching a service, which is a function of S_{ik} , is significantly decreased for almost all services from almost all providers when

[49] Again, because of the interaction terms, the data and results are effectively three-dimensional. Thus it is necessary to control for one dimension.

that service is bundled with at least one other.

Result 5 *When individuals subscribe to services as part of a bundle with other services from a single supplier, they are significantly less likely to switch provider for that service.*

The above headline result holds for almost all services with a few exceptions. Pay-TV is not significant for all providers, implying that if an individual subscribes to pay-TV through a provider other than Virgin, Sky, or Talk-Talk, then their probability of switching provider is the same irrespective of whether they bundle the service. The lack of significance of bundling for mobile telephony also implies that subscribing to other services through a mobile provider has no significant effect on the likelihood of switching provider for the mobile service. Consulting table 6.4 however indicates that the likelihood of switching is significantly negative whether bundled or not.

Conclusion

This paper has made a significant contribution in the understanding of the role of bundling in switching decisions. Through an empirical investigation this paper has produced two key results concerning empirical specification and the role of bundling of services in affecting the switching decisions of consumers.

Result 4 *Models featuring service- and supplier-specific variables outperform those which are constructed mainly using demographic variables, however controlling for these variables in a service-specific model results in a better fit than service variables alone.*

Result 5 *When individuals subscribe to services as part of a bundle with other services from a single supplier, they are significantly less likely to switch provider for that service.*

The second result has particular significance in its potential to guide regulators' policy decisions. In comparing tables 6.4 and 6.5 two significant empirical facts are illustrated: they readily show that the likelihood of someone switching a service provided by a small firm (from the 'other' category) is almost always higher than the equivalent from a large supplier; they also show that this effect is magnified if the large operator is able to bundle and the small firm not.

In order to alleviate this second effect it must be the case that all firms have the ability to offer multiple services and specifically they must be able to overcome both the barriers to entry which prevent firms from entering some markets, particularly pay-TV or mobile telecommunications; both of which are relatively concentrated markets.

Recent technological advances have made the broadcast of subscription television easier through delivery methods such as online streaming of content. Despite this, the incumbent TV operators have further advantages in their provision through the content that is typically only available to subscribers to the major operators. Although regulatory policy in the UK requires that Sky offer mandated access to its premium

content, the psychological association between the broadcast and broadcaster cannot readily be overcome.

Although this study has shown that bundling of services reduces switching, a key variable which was not included (owing to the design of the survey from which the data was gathered) was price or discount. It is well established that bundled products are frequently sold at a discount to the sum of the equivalent standalone products; in this respect the welfare reducing effects stemming from the increased switching costs of bundling may be outweighed by the positive welfare gains that stem from lower prices. Though this argument rests heavily on the notion that the firms which offer bundles do not artificially increase the standalone prices in order to exaggerate the belief that a bundle offers better value.

Although the result of the model are very significant the dataset was limited by the absence of certain variables which have been proven to be very significant in previous studies, the foremost amongst these being price. The pecuniary incentives associated with switching services cannot be underestimated. Similarly, measures of quality and satisfaction would provide additional insight into 'push factors' which drive individuals to seek out new suppliers.

Despite some data shortcomings this paper has produced a set of robust findings concerning the impact of bundling on switching, indicating that consumers are significantly less likely to switch provider of a bundled service. It has also shown that there is definite heterogeneity between firms and services in the likelihood of switching, indicating that the assumption of homogeneity in this respect is flawed. In relation to this last point, this paper has shown that models containing provider-specific variables outperform those that don't.

Final Remarks

Final Remarks

This study focussed on two key areas; the distribution decisions of a high-tech firm, and the difficulties faced by consumers in purchasing communication services. There were significant results in both cases.

It was found that the market structure has a significant impact on the durability of exclusive distribution agreements for the distribution of the iPhone mobile phone. Further that the market structure also affects the ability to even sell the phone into a particular market.

From the perspective of consumers, it was found that practices implemented by firms, such as the decision to bundle technological services we very significant in consumers ability or willingness to change supplier.

Both studies illustrated case studies with features that, if not exclusive to the provision of high-tech goods and services, are common to much of their distribution.

These studies are themselves particularly significant as standalone exercises, both in terms of results, but also methodology. The investigations are themselves not research 'dead-ends'. Both open the door to range of further analyses and can act as a springboard to long-term research agendas.

Finally, this study has focussed on the difficulties of optimal distribution, or potential pernicious outcomes stemming from the way in which technology services are supplied. This, however, should not distract the reader from the knowledge that technology has, and continues to have, a profoundly positive impact. The challenge for firms, regulators, and ultimately consumers, is to deal with the externalities from such progress.

Appendices

A. iPhone Dataset Correlation Coefficients

	Log L& Area	Log Pop. Density	Log GDP/Capita	Africa	North America	South America	Asia	Aus & Oceania
Log L& Area	1							
Log Pop. Density	-0.72	1						
Log GDP/Capita	-0.34	0.21	1					
Africa	0.15	-0.22	-0.62	1				
North America	0	-0.01	-0.04	-0.17	1			
South America	0.25	-0.27	-0.1	-0.15	-0.13	1		
Asia	-0.08	0.41	-0.03	-0.21	-0.19	-0.17	1	
Aus & Oceania	0.14	-0.26	0.15	-0.07	-0.06	-0.05	-0.08	1
Europe	-0.26	0.09	0.52	-0.34	-0.31	-0.28	-0.39	-0.13
Num. Firms	0.33	-0.01	0.03	-0.16	0.19	-0.03	0.13	-0.08
HHI	-0.07	-0.11	-0.22	0.2	0.06	0.02	0.01	0.02
Competing St&ards	0.27	-0.09	0.01	-0.17	0.37	0.21	-0.01	0.17
Mobiles per 100	-0.37	0.26	0.7	-0.59	-0.15	-0.07	0.21	0.03
Vendor Position	-0.01	-0.04	-0.46	0.35	-0.19	-0.07	0.34	-0.09
Delay from launch	-0.01	-0.06	-0.09	0.07	-0.07	0.23	-0.02	-0.05

	Europe	Num. Firms	HHI	Competing St&ards	Mobiles per 100	Vendor Position	Delay from launch
Log L& Area							
Log Pop. Density							
Log GDP/Capita							
Africa							
North America							
South America							
Asia							
Aus & Oceania							
europe	1						
Num. Firms	-0.08	1					
HHI	-0.22	-0.64	1				
Competing St&ards	-0.31	0.39	-0.17	1			
Mobiles per 100	0.41	-0.1	-0.07	-0.24	1		
Vendor Position	-0.33	-0.23	0.37	-0.21	-0.19	1	
Delay from launch	-0.12	0.07	-0.05	-0.11	-0.05	0.29	1

B. iPhone Collection Dataset

The overleaf table contains collected data concerning the date at which different operators in different countries started selling the iPhone. There are a number of operators for which the there was no firm evidence available; none of these operators are core to the study (mainly being later entrants beyond the scope of the investigation).

The fields are as follows:

Field	Description
Country	The country
Operator	The network operator which is selling the iPhone
Date	The date at which the iPhone was first sold by the relevant operator
Include	Whether this country is taken into account in the analysis. If it is not included this may be because the iPhone was launched outside the window for which broader data is available, or because there are variables missing for this country.
Evidence	Sources which supportbthe launch date proposed.

Country	Operator	Date	Include	Evidence
Anguilla	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
Antigua & Barbuda	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
Argentina	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931
Argentina	Movistar	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09americamovil.html http://in.reuters.com/article/idINL636498620080806
Argentina	Personal Telecom	27 Sep 10	1	http://www.apple.com/la/iphone/buy/#ar http://www.telecompaper.com/news/personal-launches-iphone-4-in-argentina
Armenia	Orange	1 Apr 10	0	http://goarmenia.net/2010/04/01/orange-armenia-announced-launch-of-iphone-sales/ http://www.armeni\&iaspora.com/showthread.php?227780-IPhones-Now-Available-In-Armenia-But-Only-For-Orange-Customers-
Australia	Virgin Mobile	4 Aug 08	1	
Australia	Vodafone	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html
Australia	Sing Tel/Optus	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09optus.html
Australia	Telstra	30 Jul 08	1	http://www.telstra.com.au/abouttelstra/media-centre/announcements/telstra-to-bring-iphone-4-to-australia-on-july-30.xml
Austria	TAG	29 Nov 10	1	http://www.telekomaustria.com/presse/news/2010/1125-iphone-launch.php
Austria	Orange	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09orange.html
Austria	H3G	29 Nov 10	1	http://www.telecompaper.com/news/3-austria-has-around-10000-iphone-users-ceo http://blogs.strategyanalytics.com/trs/?p=33
Austria	T-Mobile	14 Mar 08	1	http://www.talkiphone.com/iphone-austria-march-14th-tmobile-315/
Bahrain	Viva	11 May 11		http://jazarah.net/viva-to-bring-iphone-4-to-bahrain-on-may-15/
Bahrain	Zain	12 Jun 11		http://www.zain.com/media-centre/press-releases/zain-launches-iphone-4-in-kuwait-jordan-\&-bahrain/
Belgium	KPN	30 Oct 09	1	http://www.kpngroup.be/public/uploads/files/persberichten/en/Press\%20release\%2023102009\%20-\%20BASE\%20iphone\%20(final_ENG).pdf
Belgium	Mobistar/Orange	11 Jul 08	1	http://www.reuters.com/article/idUSL0859270920080708
Botswana	Orange	18 Dec 08	1	http://www.apple.com/befr/iphone/buy/ http://tech.fortune.cnn.com/2008/05/16/france-telecom-to-carry-apples-iphone-to-africa-\&-beyond/ http://www.apple.com/bw/buy/
Brazil	Claro	22 Aug 08	1	http://www.telefonica.com/en/shareholders_investors/pdf/080710_iPhone_TEspana_eng.pdf
Brazil	TIM	15 Dec 08	1	http://www.reuters.com/article/idUSN0648325420080806
Brazil	Movistar	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09americamovil.html http://wirelessfederation.com/news/13857-tim-launches-iphone-3g-for-its-subscribers-in-brazil/
British Virgin Islands	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
Bulgaria	Globul	20 Mar 09	1	http://www.telekomaustria.com/presse/news/2010/1125-iphone-launch.php
Bulgaria	Mobiltel/TAG	29 Nov 10	1	http://sofiaecho.com/2009/03/13/688818_globul-announces-official-introduction-of-iphone-in-bulgaria
Cameroon	Orange	18 Jun 09	1	http://tech.fortune.cnn.com/2008/05/16/france-telecom-to-carry-apples-iphone-to-africa-\&-beyond/ http://www.apple.com/cm/buy/

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Country	Operator	Date	Include	Evidence
Canada	Rogers	11 Jul 08	1	http://www.bce.ca/en/news/releases/bm/2009/10/06/75222.html http://www.iphoneincanada.ca/carriers/telus-carriers/apple-acknowledges-telus-as-an-iphone-carrier/ #
Canada	Telus	5 Nov 08	1	http://www.apple.com/cm/buy/ http://www.apple.com/pr/library/2008/06/09rogers.html
Canada	Bell	4 Nov 08	1	http://about.telus.com/cgi-bin/media_news_viewer.cgi?news_id=1135\&mode=2 http://www.iphoneincanada.ca/carriers/telus-carriers/apple-acknowledges-telus-as-an-iphone-carrier/ #
Cayman Islands	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\ %20launch-170611.pdf
Central African Republic	Orange	18 Jun 09	1	http://www.apple.com/cf/buy/
Chile	Movistar	22 Aug 08	1	http://in.reuters.com/article/idINL636498620080806 http://saladeprensa.telefonica.es/documentos/iPhone_global_eng.pdf
Chile	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931 http://www.apple.com/pr/library/2008/06/09americamovil.html
China	Unicom	1 Oct 09	1	http://www.engadget.com/2009/09/28/china-unicom-readies-october-1st-iphone-launch/
China	China Telecom	9 Mar 12	1	http://www.chinatelecom-h.com/eng/media/news/p120221.pdf
Colombia	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931 http://www.apple.com/pr/library/2008/06/09americamovil.html
Colombia	Movistar	22 Aug 08	1	http://in.reuters.com/article/idINL636498620080806 http://saladeprensa.telefonica.es/documentos/iPhone_global_eng.pdf
Côte d'Ivoire	Orange	18 Jun 09	1	http://www.apple.com/ci/buy/
Croatia	TAG	Nov 10?	1	http://www.telekomaustria.com/presse/news/2010/1005-iphone_en.php
Croatia	T-Mobile	7 Nov 08	1	http://www.iphoneworld.ca/news/2008/10/29/t-mobile-to-launch-iphone-3g-in-croatia-on-november-7/ # http://www.apple.com/pr/library/2008/06/09tmobile.html
Czech Republic	Vodafone	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html
Czech Republic	T-Mobile	22 Aug 08	1	http://arstechnica.com/apple/news/2008/09/iphone-3g-sales-in-czech-republic-very-small-despite-heavy-marketing. ars
Czech Republic	Telefonica	22 Aug 08	1	http://www.telefonica.com/en/shareholders_investors/pdf/080710_iPhone_TEspana_eng.pdf http://moconews.net/article/419-iphone-to-launch-22-august-in-india-estonia-\ &-the-czech-republic/
Denmark	TDC	30 Jul 10	1	http://www.apple.com/pr/library/2008/06/09teliasonera.html
Denmark	TeliaSonera	11 Jul 08	1	http://www.tipb.com/2010/07/26/apple-officially-announces-australia-austria-belgium-canada-denmark-finl\ &-hong-kong-irel\&-italy-luxembourg-netherl\&s-norway-zeal\ &-singapore-spain-sweden-switzerl\&/
Denmark	Telenor	20 Mar 09	1	http://tdc.com/publish.php?id=25584 http://www.tipb.com/2010/07/26/apple-officially-announces-australia-austria-belgium-canada-denmark-finl\ &-hong-kong-irel\&-italy-luxembourg-netherl\&s-norway-zeal\ &-singapore-spain-sweden-switzerl\&/
Denmark	H3G	30 Jul 10	1	http://telenor.com/en/news-\&-media/press-releases/2009/telenor-bring-iphone-3G-to-norway
Dominica	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\ %20launch-170611.pdf
Dominican Republic	Orange	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09orange.html
Dominican Republic	Claro	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09americamovil.html

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Country	Operator	Date	Include	Evidence
Ecuador	Movistar	22 Aug 08	1	http://in.reuters.com/article/idINL636498620080806 http://saladeprensa.telefonica.es/documentos/iPhone_global_eng.pdf
Ecuador	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931 http://www.reuters.com/article/idUSN0648325420080806
Egypt	Mobinil - Orange	15 Nov 08	1	http://tech.fortune.cnn.com/2008/05/16/france-telecom-to-carry-apples-iphone-to-africa-\ \&-beyond/ http://iphone3ghacked.com/2008/11/15/iphone-launches-on-two-carriers-in-egypt-with-no-gps/
Egypt	Vodafone	15 Nov 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html http://iphone3ghacked.com/2008/11/15/iphone-launches-on-two-carriers-in-egypt-with-no-gps/
El Salvador	Movistar	22 Aug 08	1	http://in.reuters.com/article/idINL636498620080806 http://saladeprensa.telefonica.es/documentos/iPhone_global_eng.pdf
El Salvador	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931 http://www.reuters.com/article/idUSN0648325420080806
Equatorial Guinea	Orange	2H2008	0	http://www.apple.com/gq/iphone/
Estonia	TeliaSonera	22 Aug 08	1	http://www.teliasonera.com/News-\&-Archive/Press-releases/2008/TeliaSonera-\ \&-EMT-to-bring-iPhone-3G-to-Estonia-on-August-22/
Finland	TeliaSonera	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09teliasonera.html
Finland	Elisa	28 Sep 10	1	http://www.elisa.com/on-elisa/140/130.00/16568/
France	Orange	29 Nov 07	1	http://www.apple.com/pr/library/2008/06/09orange.html http://www.orangepartner.com/site/enuk/news/p_op_newsletter_july08.jsp
France	SFR	8 Apr 09	1	http://arstechnica.com/apple/news/2009/02/frances-sfr-to-offer-iphones-starting-april-8. ars
France	Virgin Mobile	2010?	1	http://www.telecompaper.com/news/virgin-mobile-france-to-launch-iphone-4-on-17-december
France	Bouygues Telecom	29 Apr 08	1	http://wirelessfederation.com/news/14656-bouygues-telecom-to-sell-apple-iphone-in-france-from-29-april/
French Guiana	Orange	2H2008	0	?????
Germany	T-Mobile	9 Nov 07	1	http://www.apple.com/pr/library/2007/09/19iphone.html
Germany	Vodafone	27 Oct 10	1	http://online.wsj.com/article/SB10001424052748704206804575467252834463766.html?mod= googlenews_wsj http://wirelessfederation.com/news/28765-vodafone-to-sell-iphone-in-germany/
Germany	Telefonica	27 Oct 10	1	http://online.wsj.com/article/SB10001424052748704206804575467252834463766.html?mod= googlenews_wsj http://de.o2.com/ext/o2/wizard/index?page_id=16676;category_id=;state=
Greece	Cosmote	20 Mar 09	1	http://www.gsmdome.com/iphone/cosmote-launches-the-iphone-3g-in-greece-\&-bulgaria_4784# http://sofiaecho.com/2009/03/13/688818_globul-announces-official-introduction-of-iphone-in-bulgaria
Greece	Vodafone	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html
Guam	GTA Guam	11 Dec 09		http://www.businesswire.com/news/home/20091206005083/en/GTA-TeleGuam-Bring-iPhone-Guam-December-11
Guatemala	Movistar	22 Aug 08	1	http://in.reuters.com/article/idINL636498620080806 http://saladeprensa.telefonica.es/documentos/iPhone_global_eng.pdf
Guatemala	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931 http://www.reuters.com/article/idUSN0648325420080806
Guinea Republic	Orange	2H2008	0	
Guinea-Bissau	Orange	2H2008	0	
Honduras	Tigo	21 May 11	1	http://archivo.elheraldo.hn/Suplemento\%20Tecnolog\%C3\%ADa\%20del\%2021\%20de\%20mayo...
Honduras	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931

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Country	Operator	Date	Include	Evidence
				http://www.reuters.com/article/idUSN0648325420080806
Hong Kong	Broadway	11 Jul 08	1	
Hong Kong	1010	30 Jul 10	1	http://www.totaltele.com/view.aspx?ID=457384
Hong Kong	one2free	30 Jul 10	1	http://www.totaltele.com/view.aspx?ID=457384
Hong Kong	Smartone-Vodafone	23 Jan 10	1	http://www.rcrwireless.com/ARTICLE/20100127/CARRIERS/100129951/smartone-vodafone-kicks-off-iphone-availability-with-party#
Hong Kong	Hutchinson	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09hutchison.html
Hong Kong	Fortress	11 Jul 08	1	
Hungary	Vodafone	24 Sep 10	1	http://www.iphonehacks.com/2008/08/iphone3grollout.html http://www.apple.com/hu/buy/
Hungary	T-Mobile	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09tmobile.html http://www.apple.com/hu/buy/
India	SingTel	22 Aug 08	1	http://home.singtel.com/news_centre/news_releases/2008_05.12.asp
India	Bharti Airtel	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09bharti.html http://www.110words.com/520/apple-iphone-3g-india-official-launch-date-airtel-on-22nd-august/
India	Vodafone	22 Aug 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html
Indonesia	Indosat	18 May 12	1	http://www.indosat.com/Public_Relations/Press_Release_Photo_Gallery/Indosat_Apple_Hadirkan_Paket_Lengkap_iPhone_4S
Indonesia	Telkomsel	20 Mar 09	1	http://www.iphonebuzz.com/telkomsel-to-launch-iphone-3g-officially-on-march-20-126585.php http://www.apple.com/asia/iphone/buy/#id
Indonesia	XL Axiata	22 Apr 11	1	http://www.techinasia.com/xl-offers-iphone-4-in-indonesia/
Ireland	O2	14 Mar 08	1	http://www.o2.com/media/press_releases/press_release_14159.asp?archive=yes http://www.apple.com/ie/iphone/buy/
Ireland	Vodafone	25 Mar 10	1	http://www-pp.vodafone.com/content/index/press/local_press_releases/irel\&/irel\&_press_release/vodafone_irel\&_to0.html http://www.apple.com/ie/iphone/buy/
Ireland	H3G	28 Jul 10	1	http://www.three.ie/pdf/press_releases/2010/PR118\%20iPhone\%20Launch\%20Press\%20Release\%20Final.pdf http://www.apple.com/ie/iphone/buy/
Israel	Orange	10 Dec 09	0	http://www.reuters.com/article/idUSGEE5B61RP20091207?type=marketsNews http://www.apple.com/il/buy/
Israel	Pelephone	10 Dec 09	0	http://www.reuters.com/article/idUSGEE5B61RP20091207?type=marketsNews http://www.apple.com/il/buy/
Israel	Cellcom	10 Dec 09	0	http://www.reuters.com/article/idUSGEE5B61RP20091207?type=marketsNews http://www.apple.com/il/buy/
Italy	Telecom Italia SpA	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09telecomitalia.html http://www.apple.com/it/iphone/buy/
Italy	Vodafone	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html http://www.apple.com/it/iphone/buy/
Italy	H3G	?	1	http://www.tre.it/res/ext/3italia/comunicati/2009_06_19_iPhone_DEF_ENG.pdf http://www.unwiredview.com/2009/07/16/iphone-3g-s-launched-by-3-italy-for-a-good-price-\%E2\%80\%93-starting-at-e99/
Jamaica	LIME	17 Jun 11	1	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf

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Country	Operator	Date	Include	Evidence
Jamaica	Claro	22 Aug 08	1	http://www.apple.com/lae/iphone/buy/#jm
Japan	KDDI	14 Oct 11	1	http://www.channelnewsasia.com/stories/afp_asiapacific_business/view/1157361/1/.html
Japan	Softbank	11 Jul 08	1	http://www.softbankmobile.co.jp/en/news/press/2008/20080610_01/
				http://www.apple.com/jp/iphone/buy/
Jordan	Orange	18 Dec 08	1	http://www.jordantelecomgroup.jo/jtg/Home/MediaRelations/News/orange_brings_iphone/tabid/507/Default.aspx
				http://www.apple.com/jo/buy/
Jordan	Zain	15 Jun 11	1	http://telecomyou.com/blogs/entry/Zain-launches-iPhone-4-in-Jordan
Kenya	Orange	18 Jun 09	1	http://www.apple.com/ke/buy/
Korea	KT	28 Nov 09	1	http://www.bloomberg.com/apps/news?pid=newsarchive\&sid=aVmMz.1f7ETM
				http://www.apple.com/kr/iphone/buy/
Korea	SK Telecom	16 Mar 11	1	http://bgr.com/2011/03/08/koreas-sk-telecom-announces-availability-of-cdma-iphone/
Kuwait	Viva	26 Apr 11	0	http://www.socialslave.com/kuwait/viva-launches-iphone4-at-unbeatable-prices/
Kuwait	Zain	12 Jun 11	0	http://www.zain.com/media-centre/press-releases/zain-launches-iphone-4-in-kuwait-jordan-\&-bahrain/
Latvia	TeliaSonera	26 Sep 08	1	http://www.teliasonera.com/News-\&-Archive/Press-releases/2008/TeliaSonera-to-bring-iPhone-3G-to-Latvia-\&-Lithuania-on-September-26/
				http://www.reuters.com/article/idUSL2811454720080228
Liechtenstein	Swisscom	22 Aug 08	1	http://www.apple.com/li/iphone/
Liechtenstein	Orange	22 Aug 08	1	http://www.apple.com/li/iphone/emailfromorange
Lithuania	TeliaSonera	26 Sep 08	1	http://www.teliasonera.com/News-\&-Archive/Press-releases/2008/TeliaSonera-to-bring-iPhone-3G-to-Latvia-\&-Lithuania-on-September-26/
				http://www.apple.com/lt/buy/
Luxembourg	VOXmobile	26 Sep 08	1	http://www.fudgegraphics.com/2008/06/iphone-3g-still-not-coming-to-luxembourg/
Luxembourg	Tango	28 Aug 09	1	http://www.luxiphone.lu/tag/luxembourg/
				http://www.telecompaper.com/news/tango-luxembourg-to-offer-iphone-3gs-on-28-august
Luxembourg	LuxGSM	12 Dec 08	1	http://www.accessmylibrary.com/coms2/summary_0286-36061855_ITM
				http://www.pt.lu/portal/op/log/Entreprise/pid/175
Macau	Smartone	29 Nov 10	1	http://www.apple.com/asia/iphone/buy/#mo
				http://www.smartone.com.hk/about/media_centre/press_release/press/2010/11/2010_11_26_329.pdf
Macau	CTM	29 Nov 10	1	http://www.apple.com/asia/iphone/buy/#mo
				http://www.ctm.net/cgi-bin/ctm/jsp/NHS2/company_info/press/show.jsp?oid=29159
Macau	Hutchinson	22 Aug 08	1	http://www.apple.com/asia/iphone/buy/#mo
				http://www.apple.com/pr/library/2008/06/09hutchison.html
Macedonia	T-Mobile	9 Jul 09	1	http://www.apple.com/mk/iphone/
				http://reviews.cnet.com/8301-19512_7-10261481-233.html
Madagascar	Orange	26 Sep 08	1	http://tech.fortune.cnn.com/2008/05/16/france-telecom-to-carry-apples-iphone-to-africa-\&-beyond/
Malaysia	Digi	31 Mar 10	1	http://www.digi.com.my/aboutdigi/media/mr_press_det.do?id=5360\&pgPoint=4\&year=2010
				http://www.apple.com/asia/iphone/buy/#my
Malaysia	Maxis	20 Mar 09	1	http://www.maxis.com.my/mmc/index.asp?fuseaction=home.article\&aid=370\&status=1
				http://www.apple.com/asia/iphone/buy/#my

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Country	Operator	Date	Include	Evidence
Mali	Orange	26 Sep 08	1	http://www.apple.com/ml/buy/
				http://www.appleinsider.com/articles/08/09/23/apple_preparing_to_launch_iphone_in_29_more_countries.html
Malta	Vodafone	3 Oct 08	1	http://www.vodafone.com.mt/vodafone-news-details/50
				http://www.apple.com/mt/iphone/
Martinique	Orange	26 Sep 08	0	?
Mauritius	Orange	19 Dec 08	1	http://tech.fortune.cnn.com/2008/05/16/france-telecom-to-carry-apples-iphone-to-africa-\&-beyond/
				http://asheshr.com/2008/12/18/iphone-3g-in-mauritius/
Mexico	America Movil	11 Jul 08	1	http://www.prnewswire.com/news-releases/america-movil-\&-apple-to-bring-iphone-3g-to-mexico-on-july-11-57425242.html
				http://www.apple.com/mx/iphone/buy/
Mexico	Iusacell	10 Dec 10	1	http://www.iphonecation.com/iusacell-will-have-the-iphone-4-this-friday/
				http://www.apple.com/mx/iphone/buy/
Mexico	Telefonica MoviStar	27 Aug 10	1	http://modmyi.com/forums/mac-news/726348-iphone-launches-mexico-tomorrow.html
				http://www.apple.com/mx/iphone/buy/
Moldova	Moldcell	1 Feb 11	1	http://iphone.tmcnet.com/news/2011/02/01/5280456.htm
Moldova	Orange	15 Oct 08	1	http://www.telecompaper.com/news/orange-moldova-to-launch-apples-iphone-3g
				http://www.apple.com/md/iphone/
Montenegro	T-Mobile	26 Sep 08	1	http://www.apple.com/me/iphone/
Montserrat	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
Morocco	Meditel	12 Jun 11	0	http://www.iphoneislam.com/2011/06/\%D8\%A7\%D9\%84\%D8\%A2\%D9...
Netherlands	KPN	29 Nov 10	1	http://www.apple.com/nl/iphone/buy/
				http://www.dutchdailynews.com/iphone-kpn-vodafone/
Netherlands	T-Mobile	11 Jul 08	1	http://www.apple.com/nl/iphone/buy/
				http://www.apple.com/pr/library/2008/06/09tmobile.html
Netherlands	Vodafone	29 Nov 10	1	http://www.apple.com/nl/iphone/buy/
				http://www.dutchdailynews.com/iphone-kpn-vodafone/
New Zealand	Telecom NZ	11 Nov 11	1	http://www.itnews.com.au/News/279346,telecom-nz-to-retail-iphones-for-first-time.aspx
New Zealand	Vodafone	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html
				http://www.apple.com/nz/iphone/buy/
Nicaragua	Claro	22 Aug 08	1	http://www.apple.com/la/iphone/buy/#ni
Nicaragua	Telefonica	28 Sep 10	1	http://www.apple.com/la/iphone/buy/#ni
				http://www.silobreaker.com/movistar-brings-iphone-4-to-nicaragua-5_2263754185138765845
Niger	Orange	18 Jun 09	1	http://www.apple.com/ne/buy/
				http://www.apple.com/pr/library/2008/06/09orange.html
Norway	Telenor	20 Mar 09	1	http://telenor.com/en/news-\&-media/press-releases/2009/telenor-bring-iphone-3G-to-norway
				http://www.apple.com/no/iphone/buy/
Norway	TeliaSonera	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09teliasonera.html
				http://www.apple.com/no/iphone/buy/
Panama	Telefonica	7 Nov 08	1	http://www.telefonica.com/en/shareholders_investors/pdf/080710_iPhone_TEspana_eng.pdf
				http://www.centralamericadata.com/en/article/home/iPhone_3G_arrives_in_Panama
Panama	Claro	21 Oct 10	1	http://www.apple.com/la/iphone/buy/#pa

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Country	Operator	Date	Include	Evidence
				http://www.cocoas.net/cocoas/index.php?option=com_content\&view=article\&id=8378\&Itemid=81
Paraguay	Tigo	20 May 11	1	http://www.lanacion.com.py/articulo.php?art=23706
Paraguay	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931
				http://www.reuters.com/article/idUSN0648325420080806
Peru	Movistar	22 Aug 08	1	http://in.reuters.com/article/idINL636498620080806
				http://saladeprensa.telefonica.es/documentos/iPhone_global_eng.pdf
Peru	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931
				http://www.reuters.com/article/idUSN0648325420080806
Philippines	Smart Telecom	16 Dec 11	1	http://www.philstar.com/headlines/758492/smart-takes-first-bite-apple-market
Philippines	Globe Telecom	22 Aug 08	1	http://www.apple.com/asia/iphone/buy/#ph
				http://www.yugatech.com/blog/anything-apple/globe-kicks-off-iphone-3g-launch-with-a-bang/
Poland	Orange	22 Aug 08	1	http://www.reuters.com/article/idUSN215519020080821
Poland	Era T-mobile	22 Aug 08	1	http://www.reuters.com/article/idUSN215519020080821
Portugal	Orange	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09orange.html
Portugal	Vodafone	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html
Puerto Rico	AT&T	17 Oct 08	1	http://hotcellularphone.com/apple/att-to-sell-iphone-3g-in-puerto-rico-\&-us-virgin-isl\&s-on-oct-17/
Puerto Rico	Sprint	14 Oct 11	1	http://www.caribbeanbusinesspr.com/news03.php?nt_id=63032\&ct_id=1
Qatar	Vodafone	11 Dec 09	1	http://www.apple.com/qa/buy/
				http://www.saudimac.com/2009/12/qatar-finally-gets-the-iphone/
Romania	Cosmote	17 Dec 10	1	http://www.apple.com/ro/buy/
				http://www.cosmote.ro/en/pressReleasesFullStory.aspx?ns=-10009\&cid=20269
Romania	Orange	22 Aug 08	1	http://www.apple.com/ro/buy/
				http://www.orange.ro/about/archive/pr2008-0806.html
Romania	Vodafone	17 Dec 10	1	http://www.apple.com/ro/buy/
				http://www.romaniapress.com/news-10012338.html
Russia	Megaphon	3 Oct 08	1	http://themoscownews.com/news/20081003/55349680.html?referfrommn
				http://www.reuters.com/article/idUSTRE48P3BX20080926
Russia	MTS	3 Oct 08	1	http://themoscownews.com/news/20081003/55349680.html?referfrommn
				http://www.reuters.com/article/idUSTRE48P3BX20080926
Russia	Beeline	3 Oct 08	1	http://themoscownews.com/news/20081003/55349680.html?referfrommn
				http://www.reuters.com/article/idUSTRE48P3BX20080926
Saudi Arabia	STC	11 Feb 11	1	http://www.razorianfly.com/2011/02/07/saudi-telecom-company-stc-to-launch-iphone-4-feb-11/
Saudi Arabia	Mobily	23 Feb 09	1	http://www.reuters.com/article/idINL263530520090202?rpc=44
				http://www.edibleapple.com/iphone-launch-in-saudi-arabia-nets-25000-subscribers-within-hours/
Senegal	Orange	26 Sep 08	1	http://tech.fortune.cnn.com/2008/05/16/france-telecom-to-carry-apples-iphone-to-africa-\&-beyond/
Singapore	Starhub	22 aug 08	1	http://sites.starhub.com/portal/site/StarHub/menuitem.876159666306d8a8aa494b608324a5a0/..
Singapore	SingTel	22 Aug 08	1	http://home.singtel.com/news_centre/news_releases/2009_06_10.asp
				http://www.appleinsider.com/articles/08/08/12/singtel_to_launch_iphone_3g_in_singapore_on_aug_22.html
Singapore	M1	9 Dec 09	1	http://m1.com.sg/M1/site/M1Corp/menuitem.7024de8762cf9977f15a947b3f2000a0/?vgnextoid...

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Country	Operator	Date	Include	Evidence
				http://www.m1.com.sg/M1/site/M1Corp/menuitem.e2f30a2a1a1860b609b422103f2000a0/?vgnextoid=dc731b7faba72010VgnVCM100000275a160aRCRD
Slovak Republic	Orange	22 Aug 08	1	http://www.apple.com/sk/buy/ http://www.tuaw.com/2008/08/06/august-22-big-day-for-iphone-abroad/
Slovak Republic	T-Mobile	22 Aug 08	1	http://www.apple.com/sk/buy/ http://www.tuaw.com/2008/08/06/august-22-big-day-for-iphone-abroad/
South Africa	CellC	15 Jul 11	1	http://www.b\&widthblog.com/2012/07/16/cell-c-finally-gets-the-iphone/
South Africa	Vodafone	26 Sep 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html
South Africa	MTN	22 Sep 10	1	http://callquest.mtn.co.za/ProductsServices/MTN_AppleIphone/Default.aspx
Spain	Orange	28 Jul 10	1	http://www.typicallyspanish.com/news/publish/article_26338.shtml
Spain	Telefonica MoviStar	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09telefonica.html
Spain	Vodafone	28 Jul 10	1	http://www.typicallyspanish.com/news/publish/article_26338.shtml
St Kitts	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
St Lucia	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
St Vincent	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
Sweden	TeliaSonera	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09teliasonera.html
Sweden	Telenor	23 Mar 09	1	http://www.telenor.com/en/news-\&-media/press-releases/2009/telenor-signs-with-apple.jsp http://wirelessfederation.com/news/14827-telenor-sweden-begins-selling-iphone-3g/
Switzerland	Orange	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09orange.html
Switzerland	Swisscom	11 Jul 08	1	http://www.apple.com/pr/library/2008/06/09swisscom.html
Switzerland	Sunrise	30 Jul 10	1	http://www.tipb.com/2010/07/23/apple-carriers-remember-launching-iphone-4-17-countries-week/
Taiwan	Taiwan Mobile Co	15 Mar 10	0	http://www.taipeitimes.com/News/biz/archives/2010/03/11/2003467736 http://www.apple.com/tw/iphone/buy/
Taiwan	Chunghwa Telecom	13 Dec 08	0	http://www.taipeitimes.com/News/biz/archives/2008/11/29/2003429846 http://www.apple.com/tw/iphone/buy/
Taiwan	FarEastone	15 Mar 10	0	http://www.taipeitimes.com/News/biz/archives/2010/03/11/2003467735 http://www.apple.com/tw/iphone/buy/
Thailand	AIS	1 Oct 10	1	http://in.reuters.com/article/idINIndia-51384920100909 http://www.reuters.com/article/idUSSGE6880DY20100909
Thailand	True Move	16 Jan 09	1	http://www.visit-thail\&.net/News/tabid/59/ID/25/True-Moves-iPhone-3G-Mobile-Phones-Launch.aspx http://iphone.click2creation.com/2008/12/thai-true-move-to-launch-3g-iphone-on-jan-16/
Thailand	DTAC	12 Mar 10	1	http://asiancorrespondent.com/37101/dtac-officially-launches-the-iphone/#
Tunisia	Orange	24 Sep 10	0	http://www.telecompaper.com/news/orange-tunisia-launches-iphone--758847
Turkey	Turkcell	26 Sep 08	1	http://macdailynews.com/index.php/weblog/comments/18194/ http://www.apple.com/tr/buy/
Turkey	Vodafone	26 Sep 08	1	http://www.apple.com/pr/library/2008/06/09vodafone.html http://www.apple.com/tr/buy/
Turks & Caicos	lIME	17 Jun 11	0	http://www.cwc.com/assets/uploads/files/Press\%20Releases/2011/iPhone\%204\%20launch-170611.pdf
Uae	du	27 Oct 09	1	http://www.macobserver.com/tmo/article/du_launching_iphone_in_uae_on_oct_27/

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Country	Operator	Date	Include	Evidence
				http://www.apple.com/ae/buy/
Uganda	Orange	15 Dec 09	1	http://tech.fortune.cnn.com/2008/05/16/france-telecom-to-carry-apples-iphone-to-africa-\&-beyond/
UK	Vodafone	14 Jan 10	1	http://www-pp.vodafone.com/content/index/press/local_press_releases/irel\&/irel\&_press_release/vodafone_to_sell_iphone.html
				http://www.apple.com/uk/iphone/buy/
UK	T-Mobile	30 Jul 10	1	http://www.metro.co.uk/tech/836662-iphone-4-gets-t-mobile-launch
				http://www.apple.com/uk/iphone/buy/
UK	O2	9 Nov 07	1	http://www.apple.com/uk/pr/library/2007/11/061107_iphone.html
				http://www.apple.com/uk/iphone/buy/
UK	Three UK	24 Jun 10	1	http://business.timesonline.co.uk/tol/business/industry_sectors/retailing/article6952597.ece
				http://www.apple.com/uk/iphone/buy/
UK	Tesco	14 Dec 09	1	http://business.timesonline.co.uk/tol/business/industry_sectors/retailing/article6952597.ece
				http://www.apple.com/uk/iphone/buy/
UK	Orange	11 Nov 09	1	http://newsroom.orange.co.uk/2009/11/02/orange-to-bring-iphone-to-uk-on-november-10th-2/
				http://www.apple.com/uk/iphone/buy/
Uruguay	Movistar	22 Aug 08	1	http://in.reuters.com/article/idINL636498620080806
				http://saladeprensa.telefonica.es/documentos/iPhone_global_eng.pdf
Uruguay	Claro	22 Aug 08	1	http://www.3gamericas.org/index.cfm?fuseaction=pressreleasedisplay\&pressreleaseid=931
				http://www.reuters.com/article/idUSN0648325420080806
US Virgin Islands	AT&T	17 Oct 08	0	http://hotcellularphone.com/apple/att-to-sell-iphone-3g-in-puerto-rico-\&-us-virgin-isl\&s-on-oct-17/
USA	AT&T	29 Jun 07	1	http://www.usatoday.com/money/industries/telecom/2007-06-20-at\&t-iphone-push_N.htm
USA	Verizon	10 Feb 11	1	http://www.verizonwireless.com/b2c/splash/iphone.jsp
Venezuela	Movistar	14 Nov 08	1	http://macdailynews.com/index.php/weblog/comments/19124/
				http://www.apple.com/la/iphone/buy/#ve
Venezuela	Digitel	13 Jun 11	1	http://www.wayerless.com/2011/06/venezuela-el-iphone-4-ya-esta-en-digitel/
Vietnam	Viettel	26 Mar 10	0	http://www.vietnewsonline.vn/News/Society/Sci-Tech/13674/Vinaphone-Viettel-begin-iPhone-sales.htm
				http://www.telecompaper.com/news/vinaphone-viettel-to-launch-iphone-on-26-march
Vietnam	vinaphone	26 Mar 10	0	http://www.vietnewsonline.vn/News/Society/Sci-Tech/13674/Vinaphone-Viettel-begin-iPhone-sales.htm
				http://www.telecompaper.com/news/vinaphone-viettel-to-launch-iphone-on-26-march

C. Switching Random Effects Probit Results

Variable	Symbol	Specification One Coeff	SE	Specification Two Coeff	SE	Specification Three Coeff	SE
TV	$\beta_{TV,0}$	omitted		omitted		omitted	
BB	$\beta_{BB,0}$	0.806***	(0.067)	-0.308	(0.438)	-0.376	(0.439)
Mob	$\beta_{Mob,0}$	0.432***	(0.066)	1.803**	(0.723)	1.739**	(0.73)
LL	$\beta_{LL,0}$	0.374***	(0.067)	-1.289***	(0.462)	-1.362***	(0.463)
BT × TV	$\beta_{TV,1}$	-	-	omitted		omitted	
BT × BB	$\beta_{BB,1}$	-	-	omitted		omitted	
BT × Mob	$\beta_{Mob,1}$	-	-	omitted		omitted	
BT × LL	$\beta_{LL,1}$	-	-	omitted		omitted	
Sky × TV	$\beta_{TV,2}$	-	-	omitted		omitted	
Sky × BB	$\beta_{BB,2}$	-	-	1.87***	(0.266)	1.894***	(0.269)
Sky × Mob	$\beta_{Mob,2}$	-	-	2.201***	(0.79)	2.176***	(0.799)
Sky × LL	$\beta_{LL,2}$	-	-	2.291***	(0.278)	2.328***	(0.281)
Talk × TV	$\beta_{TV,3}$	-	-	omitted		omitted	
Talk × BB	$\beta_{BB,3}$	-	-	-0.47	(0.625)	-0.458	(0.633)
Talk × Mob	$\beta_{Mob,3}$	-	-	-0.427	(0.929)	-0.561	(0.949)
Talk × LL	$\beta_{LL,3}$	-	-	-0.015	(0.625)	0.023	(0.634)
Virg × TV	$\beta_{TV,4}$	-	-	omitted		omitted	
Virg × BB	$\beta_{BB,4}$	-	-	0.41	(0.269)	0.451*	(0.272)
Virg × Mob	$\beta_{Mob,4}$	-	-	0.102	(0.444)	0.095	(0.446)
Virg × LL	$\beta_{LL,4}$	-	-	1.023***	(0.271)	1.085***	(0.274)
Mobfirm × TV	$\beta_{TV,5}$	-	-	omitted		omitted	
Mobfirm × BB	$\beta_{BB,5}$	-	-	-0.325	(1.025)	-0.216	(1.025)
Mobfirm × Mob	$\beta_{Mob,5}$	-	-	-0.952	(1.084)	-0.901	(1.084)
Mobfirm × LL	$\beta_{LL,5}$	-	-	0.444	(1.072)	0.489	(1.073)
Other × LL	$\beta_{TV,6}$	-	-	omitted		omitted	
Other × BB	$\beta_{BB,6}$	-	-	-0.242	(0.331)	-0.164	(0.333)
Other × Mob	$\beta_{Mob,6}$	-	-	-0.84*	(0.495)	-0.768	(0.497)
Other × LL	$\beta_{LL,6}$	-	-	0.142	(0.341)	0.276	(0.343)
Bundled × TV	$\beta_{TV,7}$	-	-	omitted		omitted	
Bundled × BB	$\beta_{BB,7}$	-	-	-1.275***	(0.197)	-1.28***	(0.198)
Bundled × Mob	$\beta_{Mob,7}$	-	-	-0.357	(0.392)	-0.379	(0.399)
Bundled × LL	$\beta_{LL,7}$	-	-	-0.556***	(0.202)	-0.587***	(0.204)
DUR Sub-6m × TV	$\beta_{TV,8}$	-	-	omitted		omitted	
DUR Sub-6m × BB	$\beta_{BB,8}$	-	-	omitted		omitted	
DUR Sub-6m × Mob	$\beta_{Mob,8}$	-	-	omitted		omitted	
DUR Sub-6m × LL	$\beta_{LL,8}$	-	-	omitted		omitted	
DUR 6m-1yr × TV	$\beta_{TV,9}$	-	-	omitted		omitted	
DUR 6m-1yr × BB	$\beta_{BB,9}$	-	-	0.361	(0.466)	0.402	(0.466)
DUR 6m-1yr × Mob	$\beta_{Mob,9}$	-	-	-2.177***	(0.679)	-2.077***	(0.688)
DUR 6m-1yr × LL	$\beta_{LL,9}$	-	-	0.405	(0.496)	0.434	(0.497)
DUR 1yr-2yr × TV	$\beta_{TV,10}$	-	-	omitted		omitted	
DUR 1yr-2yr × BB	$\beta_{BB,10}$	-	-	0.498	(0.413)	0.545	(0.414)
DUR 1yr-2yr × Mob	$\beta_{Mob,10}$	-	-	-1.604***	(0.625)	-1.475**	(0.633)

Continued on next page

Table C.1 – continued from previous page

		Specification One		Specification Two		Specification Three	
Variable	Symbol	Coeff	SE	Coeff	SE	Coeff	SE
DUR 1yr-2yr × LL	$\beta_{LL,10}$	-	-	0.452	(0.446)	0.521	(0.446)
DUR 2yr-4yr × TV	$\beta_{TV,11}$	-	-	omitted		omitted	
DUR 2yr-4yr × BB	$\beta_{BB,11}$	-	-	0.667	(0.425)	0.653	(0.425)
DUR 2yr-4yr × Mob	$\beta_{Mob,11}$	-	-	-1.85***	(0.637)	-1.796***	(0.645)
DUR 2yr-4yr × LL	$\beta_{LL,11}$	-	-	0.773*	(0.455)	0.78*	(0.456)
DUR over-4yr × TV	$\beta_{TV,13}$	-	-	omitted		omitted	
DUR over-4yr × BB	$\beta_{BB,13}$	-	-	0.705*	(0.412)	0.778*	(0.412)
DUR over-4yr × Mob	$\beta_{Mob,13}$	-	-	-1.779***	(0.628)	-1.65***	(0.637)
DUR over-4yr × LL	$\beta_{LL,13}$	-	-	0.722	(0.442)	0.817*	(0.442)
DUR Don't know × TV	$\beta_{TV,14}$	-	-	omitted		omitted	
DUR Don't know × BB	$\beta_{BB,14}$	-	-	1.246**	(0.559)	1.313**	(0.561)
DUR Don't know × Mob	$\beta_{Mob,14}$	-	-	-1.627*	(0.856)	-1.562*	(0.869)
DUR Don't know × LL	$\beta_{LL,14}$	-	-	0.923	(0.596)	0.994*	(0.597)
Bundled × BT	$\beta_{BT,15}$	-	-	omitted		omitted	
Bundled × Sky	$\beta_{Sky,15}$	-	-	-0.376*	(0.218)	-0.363*	(0.22)
Bundled × Talk	$\beta_{Talk,15}$	-	-	-0.475**	(0.239)	-0.53**	(0.242)
Bundled × Virg	$\beta_{Virg,15}$	-	-	-1.236***	(0.204)	-1.237***	(0.206)
Bundled × Mobfirm	$\beta_{MobF,15}$	-	-	0.168	(0.414)	0.07	(0.418)
Bundled × Other	$\beta_{Oth,15}$	-	-	0.189	(0.208)	0.155	(0.211)
DUR Sub-6m × BT	$\beta_{BT,16}$	-	-	omitted		omitted	
DUR Sub-6m × Sky	$\beta_{Sky,16}$	-	-	omitted		omitted	
DUR Sub-6m × Talk	$\beta_{Talk,16}$	-	-	omitted		omitted	
DUR Sub-6m × Virg	$\beta_{Virg,16}$	-	-	omitted		omitted	
DUR Sub-6m × Mobfirm	$\beta_{MobF,16}$	-	-	omitted		omitted	
DUR Sub-6m × Other	$\beta_{Oth,16}$	-	-	omitted		omitted	
DUR 6m-1yr × BT	$\beta_{BT,17}$	-	-	omitted		omitted	
DUR 6m-1yr × Sky	$\beta_{Sky,17}$	-	-	-0.253	(0.532)	-0.28	(0.533)
DUR 6m-1yr × Talk	$\beta_{Talk,17}$	-	-	-0.415	(0.601)	-0.537	(0.604)
DUR 6m-1yr × Virg	$\beta_{Virg,17}$	-	-	0.984*	(0.572)	0.893	(0.573)
DUR 6m-1yr × Mobfirm	$\beta_{MobF,17}$	-	-	3.191***	(0.791)	3.083***	(0.799)
DUR 6m-1yr × Other	$\beta_{Oth,17}$	-	-	1.563***	(0.576)	1.632***	(0.582)
DUR 1yr-2yr × BT	$\beta_{BT,18}$	-	-	omitted		omitted	
DUR 1yr-2yr × Sky	$\beta_{Sky,18}$	-	-	0.129	(0.465)	0.151	(0.466)
DUR 1yr-2yr × Talk	$\beta_{Talk,18}$	-	-	-0.888*	(0.517)	-0.962*	(0.52)
DUR 1yr-2yr × Virg	$\beta_{Virg,18}$	-	-	0.7	(0.524)	0.741	(0.525)
DUR 1yr-2yr × Mobfirm	$\beta_{MobF,18}$	-	-	2.536***	(0.742)	2.447***	(0.751)
DUR 1yr-2yr × Other	$\beta_{OthT,18}$	-	-	0.84	(0.527)	0.886*	(0.534)
DUR 2yr-4yr × BT	$\beta_{BT,19}$	-	-	omitted		omitted	
DUR 2yr-4yr × Sky	$\beta_{Sky,19}$	-	-	-0.231	(0.479)	-0.252	(0.48)
DUR 2yr-4yr × Talk	$\beta_{Talk,19}$	-	-	-1.176**	(0.521)	-1.258**	(0.524)
DUR 2yr-4yr × Virg	$\beta_{Virg,19}$	-	-	0.609	(0.525)	0.623	(0.526)
DUR 2yr-4yr × Mobfirm	$\beta_{MobF,19}$	-	-	2.56***	(0.745)	2.469***	(0.753)
DUR 2yr-4yr × Other	$\beta_{Oth,19}$	-	-	0.51	(0.527)	0.518	(0.533)
DUR over-4yr × BT	$\beta_{BT,20}$	-	-	omitted		omitted	
DUR over-4yr × Sky	$\beta_{Sky,20}$	-	-	-0.112*	(0.461)	-0.084	(0.461)
DUR over-4yr × Talk	$\beta_{Talk,20}$	-	-	-1.181**	(0.519)	-1.301**	(0.521)
DUR over-4yr × Virg	$\beta_{Virg,20}$	-	-	-0.02	(0.511)	-0.063	(0.512)
DUR over-4yr × Mobfirm	$\beta_{MobF,20}$	-	-	2.41***	(0.739)	2.231***	(0.747)
DUR over-4yr × Other	$\beta_{Oth,20}$	-	-	0.457	(0.52)	0.423	(0.525)
DUR Don't know × BT	$\beta_{BT,21}$	-	-	omitted		omitted	
DUR Don't know × Sky	$\beta_{Sky,21}$	-	-	0.229	(0.698)	0.266	(0.707)
DUR Don't know × Talk	$\beta_{Talk,21}$	-	-	-6.349	(541.401)	-6.107	(355.187)
DUR Don't know × Virg	$\beta_{Virg,21}$	-	-	0.976	(0.649)	1.096*	(0.654)
DUR Don't know × Mobfirm	$\beta_{MobF,21}$	-	-	1.831*	(1.027)	1.841*	(1.04)
DUR Don't know × Other	$\beta_{Oth,21}$	-	-	1.034	(0.65)	1.101*	(0.656)
Bundled	β_{22}	-	-	0.262	(0.374)	0.344	(0.377)
Bundled × DUR Sub-6m	β_{23}	-	-	omitted		omitted	
Bundled × DUR 6m-1yr	β_{24}	-	-	0.099	(0.393)	0.08	(0.396)
Bundled × DUR 1yr-2yr	β_{25}	-	-	-0.414	(0.345)	-0.469	(0.348)
Bundled × DUR 2yr-4yr	β_{26}	-	-	-0.526	(0.35)	-0.538	(0.352)
Bundled × DUR over-4yr	β_{27}	-	-	0.508	(0.339)	0.434	(0.342)

Continued on next page

Table C.1 – continued from previous page

Variable	Symbol	Specification One Coeff	SE	Specification Two Coeff	SE	Specification Three Coeff	SE
Bundled × DUR Don't know	β_{28}	-	-	1.09**	(0.492)	1.107**	(0.498)
DUR Sub-6m	β_{29}	-	-	omitted		omitted	
DUR 6m-1yr	β_{30}	-	-	-0.16	(0.525)	-0.206	(0.528)
DUR 1yr-2yr	β_{31}	-	-	0.334	(0.473)	0.277	(0.475)
DUR 2yr-4yr	β_{32}	-	-	0.634	(0.483)	0.642	(0.484)
DUR over-4yr	β_{33}	-	-	0.005	(0.466)	0.038	(0.468)
DUR Don't know	β_{34}	-	-	-0.983	(0.656)	-1.013	(0.66)
INCOME sub-11500	γ_1	omitted		-	-	omitted	
INCOME 11500-17499	γ_2	0.161	(0.113)	-	-	0.163	(0.122)
INCOME 17500-29999	γ_3	0.276***	(0.103)	-	-	0.24**	(0.111)
INCOME 30000-49999	γ_4	0.225**	(0.106)	-	-	0.2*	(0.114)
INCOME 50000+	γ_5	0.117	(0.123)	-	-	0.027	(0.133)
INCOME Don't know	γ_6	-0.008	(0.119)	-	-	0.049	(0.129)
INCOME Refused	γ_7	-0.371***	(0.103)	-	-	-0.341***	(0.111)
Children	γ_8	-0.148**	(0.063)	-	-	-0.137**	(0.068)
EMPLOY Full-time	γ_9	omitted		-	-	omitted	
EMPLOY Part-time	γ_{10}	0.062	(0.079)	-	-	0.045	(0.086)
EMPLOY Looking	γ_{11}	0.156	(0.157)	-	-	0.051	(0.169)
EMPLOY Education	γ_{12}	-0.109	(0.172)	-	-	-0.135	(0.187)
EMPLOY Retired	γ_{13}	0.071	(0.105)	-	-	0.077	(0.112)
EMPLOY Not	γ_{14}	-0.04	(0.087)	-	-	-0.062	(0.094)
EMPLOY Refused	γ_{15}	-0.141	(0.337)	-	-	-0.191	(0.367)
Gender	γ_{16}	-0.065	(0.054)	-	-	-0.092	(0.059)
EDU under-17	γ_{17}	omitted		-	-	omitted	
EDU 17-18	γ_{18}	0.115	(0.071)	-	-	0.143*	(0.077)
EDU 19-20	γ_{19}	0.254***	(0.094)	-	-	0.251**	(0.102)
EDU 21+	γ_{20}	0.173**	(0.07)	-	-	0.123	(0.076)
EDU Don't know	γ_{21}	-0.12	(0.269)	-	-	-0.018	(0.293)
EDU Refused	γ_{22}	0.507	(0.431)	-	-	0.818*	(0.469)
AGE under-18	γ_{23}	-0.458	(0.293)	-	-	-0.508	(0.315)
AGE 18-24	γ_{24}	omitted		-	-	omitted	
AGE 25-34	γ_{25}	0.061	(0.118)	-	-	0.037	(0.128)
AGE 35-44	γ_{26}	-0.095	(0.122)	-	-	-0.09	(0.133)
AGE 45-54	γ_{27}	-0.073	(0.121)	-	-	-0.018	(0.132)
AGE 55-64	γ_{28}	-0.155	(0.13)	-	-	-0.143	(0.142)
AGE 65-74	γ_{29}	-0.222	(0.153)	-	-	-0.265	(0.165)
AGE 75+	γ_{30}	-0.674***	(0.213)	-	-	-0.74***	(0.229)
Constant	α	-1.798***	(0.159)	-0.924*	(0.481)	-0.869*	(0.507)
n		2856		2856		2856	
obs		8628		8628		8628	
Log-likelihood		-3202.75		-2860.89		-2806.28	

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

D. Full Expected Values of S_{ik} for Specifications Two and Three

				Specification Two		Specification Three	
Supplier	Service	Duration	Bundled	Fitted S_{ik}	SE	Fitted S_{ik}	SE
BT	Pay-TV	6 months or under	No	-0.924 *	(0.481)	-0.632	(0.495)
BT	Pay-TV	6 months or under	Yes	-0.662	(0.531)	-0.289	(0.546)
BT	Pay-TV	7 to 12 months	No	-1.084 ***	(0.329)	-0.837 **	(0.349)
BT	Pay-TV	7 to 12 months	Yes	-0.723 **	(0.357)	-0.415	(0.376)
BT	Pay-TV	13 to 24 months	No	-0.589 **	(0.267)	-0.356	(0.29)
BT	Pay-TV	13 to 24 months	Yes	-0.742 ***	(0.265)	-0.481 *	(0.289)
BT	Pay-TV	25 to 48 months	No	-0.289	(0.293)	0.01	(0.316)
BT	Pay-TV	25 to 48 months	Yes	-0.554 *	(0.291)	-0.184	(0.315)
BT	Pay-TV	Over 48 months	No	-0.919 ***	(0.277)	-0.594 **	(0.3)
BT	Pay-TV	Over 48 months	Yes	-0.149	(0.251)	0.184	(0.276)
BT	Pay-TV	Don't know	No	-1.907 ***	(0.537)	-1.645 **	(0.551)
BT	Pay-TV	Don't know	Yes	-0.555	(0.563)	-0.194	(0.579)
BT	Broadband	6 months or under	No	-1.232 ***	(0.365)	-1.008 ***	(0.38)
BT	Broadband	6 months or under	Yes	-2.245 ***	(0.418)	-1.944 ***	(0.431)
BT	Broadband	7 to 12 months	No	-1.031 ***	(0.263)	-0.812 ***	(0.287)
BT	Broadband	7 to 12 months	Yes	-1.944 ***	(0.283)	-1.669 ***	(0.302)
BT	Broadband	13 to 24 months	No	-0.399 **	(0.166)	-0.187	(0.198)
BT	Broadband	13 to 24 months	Yes	-1.826 ***	(0.178)	-1.592 ***	(0.209)
BT	Broadband	25 to 48 months	No	0.07	(0.154)	0.287	(0.189)
BT	Broadband	25 to 48 months	Yes	-1.469 ***	(0.186)	-1.187 ***	(0.218)
BT	Broadband	Over 48 months	No	-0.522 ***	(0.145)	-0.192	(0.185)
BT	Broadband	Over 48 months	Yes	-1.027 ***	(0.146)	-0.694 ***	(0.184)
BT	Broadband	Don't know	No	-0.969 ***	(0.376)	-0.708 *	(0.393)
BT	Broadband	Don't know	Yes	-0.892 **	(0.4)	-0.537	(0.419)
BT	Mobile	6 months or under	No	0.879	(0.729)	1.107	(0.742)
BT	Mobile	6 months or under	Yes	0.784	(0.821)	1.071	(0.835)
BT	Mobile	7 to 12 months	No	-1.458 ***	(0.481)	-1.176 **	(0.493)
BT	Mobile	7 to 12 months	Yes	-1.454 **	(0.569)	-1.132 *	(0.584)
BT	Mobile	13 to 24 months	No	-0.391	(0.384)	-0.092	(0.4)
BT	Mobile	13 to 24 months	Yes	-0.901 *	(0.485)	-0.597	(0.501)
BT	Mobile	25 to 48 months	No	-0.336	(0.391)	-0.048	(0.405)
BT	Mobile	25 to 48 months	Yes	-0.958 *	(0.507)	-0.621	(0.524)
BT	Mobile	Over 48 months	No	-0.895 **	(0.378)	-0.506	(0.395)
BT	Mobile	Over 48 months	Yes	-0.483	(0.46)	-0.107	(0.477)
BT	Mobile	Don't know	No	-1.731 **	(0.74)	-1.469 *	(0.757)
BT	Mobile	Don't know	Yes	-0.737	(0.843)	-0.397	(0.863)
BT	Landline	6 months or under	No	-2.213 ***	(0.319)	-1.994 ***	(0.338)
BT	Landline	6 months or under	Yes	-2.507 ***	(0.396)	-2.238 ***	(0.413)
BT	Landline	7 to 12 months	No	-1.968 ***	(0.25)	-1.766 ***	(0.274)
BT	Landline	7 to 12 months	Yes	-2.163 ***	(0.279)	-1.93 ***	(0.299)
BT	Landline	13 to 24 months	No	-1.427 ***	(0.166)	-1.197 ***	(0.196)
BT	Landline	13 to 24 months	Yes	-2.135 ***	(0.184)	-1.909 ***	(0.213)
BT	Landline	25 to 48 months	No	-0.806 ***	(0.144)	-0.572 ***	(0.178)
BT	Landline	25 to 48 months	Yes	-1.626 ***	(0.183)	-1.354 ***	(0.215)
BT	Landline	Over 48 months	No	-1.487 ***	(0.079)	-1.139 ***	(0.135)

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Table D.1 – continued from previous page

Supplier	Service	Duration	Bundled	Specification Two Fitted S_{ik}	SE	Specification Two Fitted S_{ik}	SE
BT	Landline	Over 48 months	Yes	-1.273 ***	(0.141)	-0.948 ***	(0.178)
BT	Landline	Don't know	No	-2.274 ***	(0.362)	-2.012 ***	(0.388)
BT	Landline	Don't know	Yes	-1.478 ***	(0.407)	-1.149 ***	(0.428)
Sky	Pay-TV	6 months or under	No	-2.265 ***	(0.322)	-2.023 ***	(0.339)
Sky	Pay-TV	6 months or under	Yes	-2.379 ***	(0.405)	-2.043 ***	(0.416)
Sky	Pay-TV	7 to 12 months	No	-2.678 ***	(0.331)	-2.509 ***	(0.35)
Sky	Pay-TV	7 to 12 months	Yes	-2.693 ***	(0.356)	-2.449 ***	(0.372)
Sky	Pay-TV	13 to 24 months	No	-1.802 ***	(0.184)	-1.596 ***	(0.211)
Sky	Pay-TV	13 to 24 months	Yes	-2.33 ***	(0.228)	-2.084 ***	(0.248)
Sky	Pay-TV	25 to 48 months	No	-1.862 ***	(0.183)	-1.633 ***	(0.213)
Sky	Pay-TV	25 to 48 months	Yes	-2.502 ***	(0.247)	-2.19 ***	(0.269)
Sky	Pay-TV	Over 48 months	No	-2.373 ***	(0.136)	-2.069 ***	(0.173)
Sky	Pay-TV	Over 48 months	Yes	-1.979 ***	(0.214)	-1.654 ***	(0.24)
Sky	Pay-TV	Don't know	No	-3.019 ***	(0.577)	-2.769 ***	(0.6)
Sky	Pay-TV	Don't know	Yes	-2.043 ***	(0.637)	-1.682 **	(0.664)
Sky	Broadband	6 months or under	No	-0.703 *	(0.422)	-0.506	(0.432)
Sky	Broadband	6 months or under	Yes	-2.092 ***	(0.441)	-1.805 ***	(0.448)
Sky	Broadband	7 to 12 months	No	-0.755 **	(0.331)	-0.589 *	(0.349)
Sky	Broadband	7 to 12 months	Yes	-2.044 ***	(0.316)	-1.809 ***	(0.334)
Sky	Broadband	13 to 24 months	No	0.258	(0.227)	0.467 *	(0.249)
Sky	Broadband	13 to 24 months	Yes	-1.545 ***	(0.196)	-1.301 ***	(0.219)
Sky	Broadband	25 to 48 months	No	0.367	(0.274)	0.538 *	(0.296)
Sky	Broadband	25 to 48 months	Yes	-1.547 ***	(0.238)	-1.299 ***	(0.262)
Sky	Broadband	Over 48 months	No	-0.106	(0.244)	0.227	(0.269)
Sky	Broadband	Over 48 months	Yes	-0.986 ***	(0.205)	-0.638 ***	(0.234)
Sky	Broadband	Don't know	No	-0.211	(0.55)	0.061	(0.57)
Sky	Broadband	Don't know	Yes	-0.51	(0.577)	-0.131	(0.604)
Sky	Mobile	6 months or under	No	1.739 *	(0.936)	1.892 **	(0.952)
Sky	Mobile	6 months or under	Yes	1.268	(0.989)	1.493	(1.01)
Sky	Mobile	7 to 12 months	No	-0.851	(0.784)	-0.671	(0.8)
Sky	Mobile	7 to 12 months	Yes	-1.223	(0.809)	-0.99	(0.835)
Sky	Mobile	13 to 24 months	No	0.598	(0.719)	0.844	(0.734)
Sky	Mobile	13 to 24 months	Yes	-0.288	(0.755)	-0.024	(0.779)
Sky	Mobile	25 to 48 months	No	0.293	(0.711)	0.485	(0.728)
Sky	Mobile	25 to 48 months	Yes	-0.705	(0.755)	-0.451	(0.781)
Sky	Mobile	Over 48 months	No	-0.148	(0.728)	0.196	(0.744)
Sky	Mobile	Over 48 months	Yes	-0.111	(0.756)	0.231	(0.781)
Sky	Mobile	Don't know	No	-0.642	(1.013)	-0.417	(1.035)
Sky	Mobile	Don't know	Yes	-0.023	(1.092)	0.291	(1.124)
Sky	Landline	6 months or under	No	-1.264 ***	(0.441)	-1.057 **	(0.452)
Sky	Landline	6 months or under	Yes	-1.934 ***	(0.465)	-1.664 ***	(0.475)
Sky	Landline	7 to 12 months	No	-1.272 ***	(0.362)	-1.109 ***	(0.377)
Sky	Landline	7 to 12 months	Yes	-1.842 ***	(0.331)	-1.636 ***	(0.348)
Sky	Landline	13 to 24 months	No	-0.349	(0.254)	-0.109	(0.275)
Sky	Landline	13 to 24 months	Yes	-1.433 ***	(0.212)	-1.184 ***	(0.236)
Sky	Landline	25 to 48 months	No	-0.087	(0.295)	0.113	(0.315)
Sky	Landline	25 to 48 months	Yes	-1.283 ***	(0.247)	-1.032 ***	(0.271)
Sky	Landline	Over 48 months	No	-0.65 **	(0.265)	-0.286	(0.289)
Sky	Landline	Over 48 months	Yes	-0.812 ***	(0.218)	-0.458 *	(0.246)
Sky	Landline	Don't know	No	-1.095 **	(0.522)	-0.809	(0.539)
Sky	Landline	Don't know	Yes	-0.675	(0.564)	-0.309	(0.587)
Talk-Talk	Pay-TV	6 months or under	No	0.383	(0.798)	0.81	(0.812)
Talk-Talk	Pay-TV	6 months or under	Yes	0.17	(0.791)	0.623	(0.804)
Talk-Talk	Pay-TV	7 to 12 months	No	-0.192	(0.721)	0.067	(0.736)
Talk-Talk	Pay-TV	7 to 12 months	Yes	-0.306	(0.709)	-0.04	(0.724)
Talk-Talk	Pay-TV	13 to 24 months	No	-0.171	(0.612)	0.124	(0.63)
Talk-Talk	Pay-TV	13 to 24 months	Yes	-0.799	(0.568)	-0.531	(0.585)
Talk-Talk	Pay-TV	25 to 48 months	No	-0.158	(0.683)	0.194	(0.702)
Talk-Talk	Pay-TV	25 to 48 months	Yes	-0.898	(0.653)	-0.53	(0.672)
Talk-Talk	Pay-TV	Over 48 months	No	-0.794	(0.674)	-0.454	(0.695)
Talk-Talk	Pay-TV	Over 48 months	Yes	-0.499	(0.631)	-0.206	(0.651)
Talk-Talk	Pay-TV	Don't know	No	-6.949	(541.401)	-6.31	(355.187)
Talk-Talk	Pay-TV	Don't know	Yes	-6.073	(541.401)	-5.39	(355.187)

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Table D.1 – continued from previous page

				Specification Two		Specification Two	
Supplier	Service	Duration	Bundled	Fitted S_{ik}	SE	Fitted S_{ik}	SE
Talk-Talk	Broadband	6 months or under	No	-0.395	(0.452)	-0.024	(0.465)
Talk-Talk	Broadband	6 months or under	Yes	-1.883 ***	(0.482)	-1.49 ***	(0.493)
Talk-Talk	Broadband	7 to 12 months	No	-0.609	(0.374)	-0.365	(0.393)
Talk-Talk	Broadband	7 to 12 months	Yes	-1.997 ***	(0.416)	-1.751 ***	(0.435)
Talk-Talk	Broadband	13 to 24 months	No	-0.451 *	(0.238)	-0.165	(0.266)
Talk-Talk	Broadband	13 to 24 months	Yes	-2.353 ***	(0.261)	-2.1 ***	(0.284)
Talk-Talk	Broadband	25 to 48 months	No	-0.269	(0.257)	0.014	(0.283)
Talk-Talk	Broadband	25 to 48 months	Yes	-2.283 ***	(0.286)	-1.99 ***	(0.312)
Talk-Talk	Broadband	Over 48 months	No	-0.867 ***	(0.268)	-0.509 *	(0.294)
Talk-Talk	Broadband	Over 48 months	Yes	-1.846 ***	(0.28)	-1.541 ***	(0.302)
Talk-Talk	Broadband	Don't know	No	-6.481	(541.401)	-5.831	(355.187)
Talk-Talk	Broadband	Don't know	Yes	-6.879	(541.4)	-6.19	(355.187)
Talk-Talk	Mobile	6 months or under	No	1.759 *	(0.94)	1.988 **	(0.962)
Talk-Talk	Mobile	6 months or under	Yes	1.189	(1.01)	1.422	(1.041)
Talk-Talk	Mobile	7 to 12 months	No	-0.993	(0.751)	-0.832	(0.78)
Talk-Talk	Mobile	7 to 12 months	Yes	-1.465 *	(0.824)	-1.318	(0.867)
Talk-Talk	Mobile	13 to 24 months	No	-0.399	(0.638)	-0.173	(0.664)
Talk-Talk	Mobile	13 to 24 months	Yes	-1.384 *	(0.713)	-1.208	(0.749)
Talk-Talk	Mobile	25 to 48 months	No	-0.632	(0.676)	-0.424	(0.702)
Talk-Talk	Mobile	25 to 48 months	Yes	-1.729 **	(0.761)	-1.527 **	(0.799)
Talk-Talk	Mobile	Over 48 months	No	-1.197 *	(0.66)	-0.926	(0.683)
Talk-Talk	Mobile	Over 48 months	Yes	-1.259 *	(0.73)	-1.058	(0.764)
Talk-Talk	Mobile	Don't know	No	-7.2	(541.401)	-6.695	(355.188)
Talk-Talk	Mobile	Don't know	Yes	-6.681	(541.401)	-6.154	(355.188)
Talk-Talk	Landline	6 months or under	No	-0.921 **	(0.457)	-0.529	(0.47)
Talk-Talk	Landline	6 months or under	Yes	-1.69 ***	(0.49)	-1.302 ***	(0.503)
Talk-Talk	Landline	7 to 12 months	No	-1.091 ***	(0.359)	-0.838 **	(0.377)
Talk-Talk	Landline	7 to 12 months	Yes	-1.761 ***	(0.404)	-1.532 ***	(0.423)
Talk-Talk	Landline	13 to 24 months	No	-1.023 ***	(0.233)	-0.694 ***	(0.262)
Talk-Talk	Landline	13 to 24 months	Yes	-2.207 ***	(0.258)	-1.936 ***	(0.282)
Talk-Talk	Landline	25 to 48 months	No	-0.689 ***	(0.233)	-0.365	(0.261)
Talk-Talk	Landline	25 to 48 months	Yes	-1.984 ***	(0.268)	-1.676 ***	(0.295)
Talk-Talk	Landline	Over 48 months	No	-1.376 ***	(0.245)	-0.975 ***	(0.273)
Talk-Talk	Landline	Over 48 months	Yes	-1.637 ***	(0.267)	-1.314 ***	(0.29)
Talk-Talk	Landline	Don't know	No	-7.33	(541.401)	-6.655	(355.187)
Talk-Talk	Landline	Don't know	Yes	-7.01	(541.401)	-6.321	(355.187)
Virgin	Pay-TV	6 months or under	No	-1.822 ***	(0.416)	-1.565 ***	(0.426)
Virgin	Pay-TV	6 months or under	Yes	-2.796 ***	(0.49)	-2.459 ***	(0.505)
Virgin	Pay-TV	7 to 12 months	No	-0.998 ***	(0.297)	-0.878 ***	(0.316)
Virgin	Pay-TV	7 to 12 months	Yes	-1.873 ***	(0.356)	-1.692 ***	(0.372)
Virgin	Pay-TV	13 to 24 months	No	-0.787 ***	(0.247)	-0.547 **	(0.272)
Virgin	Pay-TV	13 to 24 months	Yes	-2.176 ***	(0.261)	-1.909 ***	(0.284)
Virgin	Pay-TV	25 to 48 months	No	-0.578 **	(0.258)	-0.3	(0.28)
Virgin	Pay-TV	25 to 48 months	Yes	-2.078 ***	(0.242)	-1.731 ***	(0.263)
Virgin	Pay-TV	Over 48 months	No	-1.837 ***	(0.245)	-1.591 ***	(0.272)
Virgin	Pay-TV	Over 48 months	Yes	-2.303 ***	(0.198)	-2.05 ***	(0.227)
Virgin	Pay-TV	Don't know	No	-1.829 ***	(0.482)	-1.482 ***	(0.495)
Virgin	Pay-TV	Don't know	Yes	-1.713 ***	(0.469)	-1.269 ***	(0.485)
Virgin	Broadband	6 months or under	No	-1.719 ***	(0.449)	-1.491 ***	(0.459)
Virgin	Broadband	6 months or under	Yes	-3.968 ***	(0.518)	-3.664 ***	(0.53)
Virgin	Broadband	7 to 12 months	No	-0.534 *	(0.303)	-0.401	(0.322)
Virgin	Broadband	7 to 12 months	Yes	-2.684 ***	(0.366)	-2.495 ***	(0.38)
Virgin	Broadband	13 to 24 months	No	-0.187	(0.202)	0.072	(0.23)
Virgin	Broadband	13 to 24 months	Yes	-2.85 ***	(0.249)	-2.57 ***	(0.27)
Virgin	Broadband	25 to 48 months	No	0.192	(0.223)	0.428 *	(0.248)
Virgin	Broadband	25 to 48 months	Yes	-2.583 ***	(0.241)	-2.283 ***	(0.263)
Virgin	Broadband	Over 48 months	No	-1.029 ***	(0.201)	-0.738 ***	(0.232)
Virgin	Broadband	Over 48 months	Yes	-2.77 ***	(0.201)	-2.477 ***	(0.227)
Virgin	Broadband	Don't know	No	-0.481	(0.421)	-0.094	(0.441)
Virgin	Broadband	Don't know	Yes	-1.64 ***	(0.398)	-1.161 ***	(0.421)
Virgin	Mobile	6 months or under	No	0.083	(0.581)	0.269	(0.597)
Virgin	Mobile	6 months or under	Yes	-1.248 *	(0.722)	-1.004	(0.742)
Virgin	Mobile	7 to 12 months	No	-1.271 ***	(0.334)	-1.121 ***	(0.351)
Virgin	Mobile	7 to 12 months	Yes	-2.503 ***	(0.512)	-2.314 ***	(0.529)

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Table D.1 – continued from previous page

Supplier	Service	Duration	Bundled	Specification Two Fitted S_{ik}	SE	Specification Two Fitted S_{ik}	SE
Virgin	Mobile	13 to 24 months	No	-0.487 **	(0.224)	-0.189	(0.252)
Virgin	Mobile	13 to 24 months	Yes	-2.233 ***	(0.433)	-1.93 ***	(0.452)
Virgin	Mobile	25 to 48 months	No	-0.523 **	(0.225)	-0.262	(0.254)
Virgin	Mobile	25 to 48 months	Yes	-2.381 ***	(0.44)	-2.073 ***	(0.461)
Virgin	Mobile	Over 48 months	No	-1.711 ***	(0.217)	-1.407 ***	(0.248)
Virgin	Mobile	Over 48 months	Yes	-2.535 ***	(0.4)	-2.246 ***	(0.421)
Virgin	Mobile	Don't know	No	-1.551 **	(0.637)	-1.211 *	(0.658)
Virgin	Mobile	Don't know	Yes	-1.793 **	(0.755)	-1.377 *	(0.778)
Virgin	Landline	6 months or under	No	-2.088 ***	(0.505)	-1.842 ***	(0.513)
Virgin	Landline	6 months or under	Yes	-3.618 ***	(0.557)	-3.322 ***	(0.57)
Virgin	Landline	7 to 12 months	No	-0.859 ***	(0.325)	-0.721 **	(0.343)
Virgin	Landline	7 to 12 months	Yes	-2.29 ***	(0.364)	-2.122 ***	(0.38)
Virgin	Landline	13 to 24 months	No	-0.602 **	(0.255)	-0.303	(0.279)
Virgin	Landline	13 to 24 months	Yes	-2.546 ***	(0.254)	-2.252 ***	(0.277)
Virgin	Landline	25 to 48 months	No	-0.071	(0.247)	0.204	(0.271)
Virgin	Landline	25 to 48 months	Yes	-2.127 ***	(0.225)	-1.815 ***	(0.25)
Virgin	Landline	Over 48 months	No	-1.381 ***	(0.217)	-1.05 ***	(0.245)
Virgin	Landline	Over 48 months	Yes	-2.403 ***	(0.179)	-2.096 ***	(0.209)
Virgin	Landline	Don't know	No	-1.172	(0.436)	-0.765 *	(0.457)
Virgin	Landline	Don't know	Yes	-1.613 ***	(0.417)	-1.138 ***	(0.438)
Mobile Firm	Pay-TV	6 months or under	No	-3.216 ***	(1.225)	-2.909 **	(1.235)
Mobile Firm	Pay-TV	6 months or under	Yes	-2.786 **	(1.236)	-2.495 **	(1.246)
Mobile Firm	Pay-TV	7 to 12 months	No	-0.185	(1.068)	-0.032	(1.074)
Mobile Firm	Pay-TV	7 to 12 months	Yes	0.344	(1.072)	0.462	(1.076)
Mobile Firm	Pay-TV	13 to 24 months	No	-0.346	(1.024)	-0.185	(1.029)
Mobile Firm	Pay-TV	13 to 24 months	Yes	-0.33	(0.997)	-0.24	(0.999)
Mobile Firm	Pay-TV	25 to 48 months	No	-0.022	(1.032)	0.202	(1.037)
Mobile Firm	Pay-TV	25 to 48 months	Yes	-0.118	(1.005)	0.079	(1.008)
Mobile Firm	Pay-TV	Over 48 months	No	-0.802	(1.044)	-0.64	(1.049)
Mobile Firm	Pay-TV	Over 48 months	Yes	0.136	(1.021)	0.208	(1.024)
Mobile Firm	Pay-TV	Don't know	No	-2.368 **	(1.153)	-2.08 *	(1.165)
Mobile Firm	Pay-TV	Don't know	Yes	-0.848	(1.177)	-0.56	(1.195)
Mobile Firm	Broadband	6 months or under	No	-3.849 ***	(0.695)	-3.501 ***	(0.714)
Mobile Firm	Broadband	6 months or under	Yes	-4.694 ***	(0.825)	-4.367 ***	(0.846)
Mobile Firm	Broadband	7 to 12 months	No	-0.457	(0.286)	-0.222	(0.309)
Mobile Firm	Broadband	7 to 12 months	Yes	-1.203 **	(0.511)	-1.009 *	(0.527)
Mobile Firm	Broadband	13 to 24 months	No	-0.481 **	(0.2)	-0.233	(0.227)
Mobile Firm	Broadband	13 to 24 months	Yes	-1.74 ***	(0.419)	-1.568 ***	(0.436)
Mobile Firm	Broadband	25 to 48 months	No	0.012	(0.209)	0.264	(0.235)
Mobile Firm	Broadband	25 to 48 months	Yes	-1.359 ***	(0.43)	-1.14 **	(0.448)
Mobile Firm	Broadband	Over 48 months	No	-0.73 ***	(0.21)	-0.454 *	(0.238)
Mobile Firm	Broadband	Over 48 months	Yes	-1.067 **	(0.436)	-0.885 *	(0.454)
Mobile Firm	Broadband	Don't know	No	-1.755 **	(0.719)	-1.359 *	(0.732)
Mobile Firm	Broadband	Don't know	Yes	-1.51 *	(0.841)	-1.118	(0.866)
Mobile Firm	Mobile	6 months or under	No	-2.365 ***	(0.335)	-2.071 ***	(0.352)
Mobile Firm	Mobile	6 months or under	Yes	-2.293 ***	(0.633)	-2.037 ***	(0.652)
Mobile Firm	Mobile	7 to 12 months	No	-1.512 ***	(0.162)	-1.271 ***	(0.193)
Mobile Firm	Mobile	7 to 12 months	Yes	-1.34 ***	(0.514)	-1.157 **	(0.53)
Mobile Firm	Mobile	13 to 24 months	No	-1.099 ***	(0.086)	-0.823 ***	(0.137)
Mobile Firm	Mobile	13 to 24 months	Yes	-1.441 ***	(0.461)	-1.257 ***	(0.478)
Mobile Firm	Mobile	25 to 48 months	No	-1.021 ***	(0.088)	-0.756 ***	(0.139)
Mobile Firm	Mobile	25 to 48 months	Yes	-1.474 ***	(0.474)	-1.259 **	(0.493)
Mobile Firm	Mobile	Over 48 months	No	-1.73 ***	(0.074)	-1.452 ***	(0.13)
Mobile Firm	Mobile	Over 48 months	Yes	-1.15 **	(0.467)	-0.983 **	(0.484)
Mobile Firm	Mobile	Don't know	No	-3.144	(0.494)	-2.805 ***	(0.504)
Mobile Firm	Mobile	Don't know	Yes	-1.982 ***	(0.747)	-1.663 **	(0.769)
Mobile Firm	Landline	6 months or under	No	-4.062 ***	(0.837)	-3.782 ***	(0.852)
Mobile Firm	Landline	6 months or under	Yes	-4.188 ***	(0.903)	-3.956 ***	(0.925)
Mobile Firm	Landline	7 to 12 months	No	-0.626	(0.503)	-0.471	(0.515)
Mobile Firm	Landline	7 to 12 months	Yes	-0.652	(0.592)	-0.565	(0.608)
Mobile Firm	Landline	13 to 24 months	No	-0.739	(0.472)	-0.538	(0.486)
Mobile Firm	Landline	13 to 24 months	Yes	-1.28 **	(0.515)	-1.18 **	(0.533)
Mobile Firm	Landline	25 to 48 months	No	-0.094	(0.47)	0.109	(0.485)
Mobile Firm	Landline	25 to 48 months	Yes	-0.747	(0.517)	-0.602	(0.537)

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Supplier	Service	Duration	Bundled	Specification Two Fitted S_{ik}	Specification Two SE	Specification Two Fitted S_{ik}	Specification Two SE
Mobile Firm	Landline	Over 48 months	No	-0.926 **	(0.458)	-0.696	(0.472)
Mobile Firm	Landline	Over 48 months	Yes	-0.544	(0.516)	-0.435	(0.534)
Mobile Firm	Landline	Don't know	No	-2.291 ***	(0.839)	-1.959 **	(0.852)
Mobile Firm	Landline	Don't know	Yes	-1.327	(0.91)	-1.026	(0.935)
Other	Pay-TV	6 months or under	No	-1.276 ***	(0.48)	-1.088 **	(0.496)
Other	Pay-TV	6 months or under	Yes	-0.825	(0.61)	-0.59	(0.628)
Other	Pay-TV	7 to 12 months	No	0.127	(0.357)	0.338	(0.375)
Other	Pay-TV	7 to 12 months	Yes	0.677	(0.479)	0.916 *	(0.494)
Other	Pay-TV	13 to 24 months	No	-0.101	(0.284)	0.074	(0.305)
Other	Pay-TV	13 to 24 months	Yes	-0.065	(0.372)	0.104	(0.389)
Other	Pay-TV	25 to 48 months	No	-0.132	(0.305)	0.072	(0.324)
Other	Pay-TV	25 to 48 months	Yes	-0.207	(0.387)	0.033	(0.402)
Other	Pay-TV	Over 48 months	No	-0.814 ***	(0.294)	-0.627 **	(0.314)
Other	Pay-TV	Over 48 months	Yes	0.144	(0.37)	0.305	(0.387)
Other	Pay-TV	Don't know	No	-1.225 ***	(0.399)	-1 **	(0.416)
Other	Pay-TV	Don't know	Yes	0.316	(0.593)	0.605	(0.609)
Other	Broadband	6 months or under	No	-1.826 ***	(0.429)	-1.628 ***	(0.45)
Other	Broadband	6 months or under	Yes	-2.65 ***	(0.538)	-2.41 ***	(0.559)
Other	Broadband	7 to 12 months	No	-0.062	(0.234)	0.2	(0.259)
Other	Broadband	7 to 12 months	Yes	-0.787 **	(0.343)	-0.502	(0.361)
Other	Broadband	13 to 24 months	No	-0.153	(0.14)	0.079	(0.178)
Other	Broadband	13 to 24 months	Yes	-1.391 ***	(0.214)	-1.171 ***	(0.241)
Other	Broadband	25 to 48 months	No	-0.015	(0.134)	0.186	(0.172)
Other	Broadband	25 to 48 months	Yes	-1.364 ***	(0.232)	-1.134 ***	(0.258)
Other	Broadband	Over 48 months	No	-0.66 ***	(0.121)	-0.389 **	(0.166)
Other	Broadband	Over 48 months	Yes	-0.975 ***	(0.218)	-0.736 ***	(0.246)
Other	Broadband	Don't know	No	-0.529 *	(0.302)	-0.226	(0.326)
Other	Broadband	Don't know	Yes	-0.263	(0.485)	0.099	(0.506)
Other	Mobile	6 months or under	No	-0.313	(0.493)	-0.118	(0.513)
Other	Mobile	6 months or under	Yes	-0.219	(0.707)	0.001	(0.728)
Other	Mobile	7 to 12 months	No	-1.088 ***	(0.337)	-0.768 **	(0.355)
Other	Mobile	7 to 12 months	Yes	-0.895	(0.554)	-0.57	(0.572)
Other	Mobile	13 to 24 months	No	-0.742 ***	(0.211)	-0.431 *	(0.243)
Other	Mobile	13 to 24 months	Yes	-1.063 **	(0.453)	-0.781 *	(0.474)
Other	Mobile	25 to 48 months	No	-1.018 ***	(0.237)	-0.754 ***	(0.264)
Other	Mobile	25 to 48 months	Yes	-1.451 ***	(0.485)	-1.173 **	(0.504)
Other	Mobile	Over 48 months	No	-1.63 ***	(0.233)	-1.307 ***	(0.262)
Other	Mobile	Over 48 months	Yes	-1.029 **	(0.454)	-0.754	(0.474)
Other	Mobile	Don't know	No	-1.889 ***	(0.549)	-1.592 ***	(0.57)
Other	Mobile	Don't know	Yes	-0.705	(0.8)	-0.366	(0.822)
Other	Landline	6 months or under	No	-2.423 ***	(0.501)	-2.174 ***	(0.515)
Other	Landline	6 months or under	Yes	-2.528 ***	(0.594)	-2.263 ***	(0.611)
Other	Landline	7 to 12 months	No	-0.616 **	(0.265)	-0.314	(0.286)
Other	Landline	7 to 12 months	Yes	-0.621 *	(0.355)	-0.324	(0.372)
Other	Landline	13 to 24 months	No	-0.797 ***	(0.184)	-0.492 **	(0.215)
Other	Landline	13 to 24 months	Yes	-1.316 ***	(0.22)	-1.049 ***	(0.247)
Other	Landline	25 to 48 months	No	-0.506 ***	(0.176)	-0.234	(0.208)
Other	Landline	25 to 48 months	Yes	-1.137 ***	(0.238)	-0.861 ***	(0.265)
Other	Landline	Over 48 months	No	-1.24 ***	(0.178)	-0.896 ***	(0.211)
Other	Landline	Over 48 months	Yes	-0.837 ***	(0.23)	-0.551 **	(0.256)
Other	Landline	Don't know	No	-1.449 ***	(0.373)	-1.092 ***	(0.387)
Other	Landline	Don't know	Yes	-0.465	(0.536)	-0.074	(0.548)

Standard errors in parentheses
* (p <0.1), ** (p <0.05), *** (p <0.01)

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